5.0
ENVIRONMENTAL EFFECTS OF STATION OPERATION

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CHAPTER 5.0

ENVIRONMENTAL EFFECTS OF STATION OPERATION

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5.1 AIR EMISSION SYSTEM

The effects of air emissions from Seminole Plant Units No. 1 and No. 2 have been previously evaluated and submitted to the U. S. Environmental Protection Agency (EPA) and to the Florida Department of Environmental Regulation (DER) in the form of a Prevention of Significant Deterioration (PSD) permit application. The information reported to EPA and DER is presented in this section.

5.1.1 Description of Air Emissions

Generating Unit Emissions

The Seminole Station will be a base-load station and will operate at various levels depending on system demand. Coal burning rates and emission rates are summarized for selected operating levels in Table 5.1-1. Both maximum and minimum emission rates, corresponding to extremes in the range of coal characteristics, are shown. However, only maximum emission rates were considered in the modeling analysis used to evaluate ambient air quality impacts. The rates in Table 5.1-1 are based on both generating units operating simultaneously at the levels indicated.

The exhaust gases from each generating unit boiler will be emitted to the atmosphere through a single dual-flue stack. Exit conditions applicable to the total plume released from the stack are listed in Table 5.1-2. The FGD system is being designed for the highest availability possible. The FGD system will be designed with one complete spare module, one spare slurry pump, and selective materials that can withstand the FGD environment. Current availability figures released by the EPA for the wet limestone system indicate 82 percent availability. The current system which SECI has proposed in its PSD application should have an operational availability approaching 100 percent. This high availability value is a result of extensive spare components used throughout the system. Additional information on air emissions is provided in Appendix F.

Emissions from Other Station Sources

In addition to emissions from the main boiler stacks, there will be minor emissions from other sources. One type of particulate emission will be drift (small water droplets) from the cooling towers. Due to the efficiency of modern drift eliminators, the quality of water lost by drift is an extremely small percentage of the circulating water flow. Dissolved and suspended solids constitute only a small fraction of total droplet mass, particularly since a fresh water source (the St. Johns River) will be used for cooling tower water supply.

Another potential type of emission is fugitive dust from coal handling operations, sludge and ash disposal, and onsite traffic. Control measures that will be taken to reduce these emissions are described in Section 3.3 and in Appendix F.

5.1.2 Primary Effects of Stack Emissions

The effects of stack emissions on ambient air quality concentrations of SO_2, TSP, and NO_x were evaluated using computer modeling techniques. There are four primary objectives toward which the modeling analysis was directed:

(a) Evaluate compliance with PSD Class II increments.

(b) Evaluate compliance with Federal and State Ambient air quality standards.

(c) Determine effect of Seminole Station particulate emissions on the Jacksonville TPS attainment area.

(d) Verify to the extent allowed by modeling distance limitations that Class I increments will not be exceeded within the nearest Class I area.

Because of the nature of other sources in the area, PSD incrmenet analysis was accomplished using a single-source model considering only projected emissions from the Seminole Station. The same is true for the evaluation used to determine impacts on the Jacksonville TPS nonattainment area. Multiple-source modeling was used to assess compliance with ambient air quality standards.

5.1.2.1 Model and Input Data

A description of the modeling techniques and input data is contained in Appendix F. EPA models used were the Air Quality Display Model (U. S. Public Health Service, 1969) and the CRSTER Model (EPA, 1977b). These models are based on conventional Gaussian diffusion concepts. Such models should not be used to calculate concentrations at distances beyond 50 km from a particular emission source because of the considerable uncertainty in modeling accuracy at greater distances (EPA, 1977c).

Meteorological input data required for model operation are based largely on surface observations from the Jacksonville National Weather Service station. Upper air data from the Waycross, Georgia, balloon sounding station were also used. These were the nearest weather stations to the Putnam Site that record the detailed data needed for modeling analysis. Approval of meteorological data used was obtained from EPA Region IV and from Florida DER prior to model application.

Information on existing emission sources within the Putnam Site are of interest was obtained from the Florida DER (St. Johns River Subdistrict Office). Seminole Station emissions source data were developed by Burns and Roe, Inc., the architect/engineer for Unit No. 1.

5.1.2.2 Modeling Results

A review of regional emission source data supplied by DER indicates that the only facility which must be considered in assessing compliance with PSD increments is the Seminole Station. The PSD analysis results refer only to Seminole Station emissions. Evaluation of compliance with ambient air quality standards considers other sources in addition to the Seminole Station.

Compliance with PSD Increments - Annual Average Concentrations

Annual average SO_2 and TSP concentrations have been calculated using the Air Quality Display Model based on a load level of 75 percent of rated capacity with both units in operation. Concentrations were determined to a distance of 50 km from the Putnam Site. Maximum concentrations computed are shown in Table 5.1-3 with applicable Class II increments. Highest concentrations are negligible in comparison with the increments.

The pattern of annual concentrations, as is typical for tall stack sources, consists of almost no effect at close distance and a slight increase in concentrations at distances of about 40 to 50 km, in this case to the east of the site. However, the concentrations calculated are so low in relation to the accuracy of the model that the only firm conculsion which can be drawn regarding geographic distribution is that concentrations are estimated to be uniformly low for all directions and distances.

Complaince with PSD Increments - 24-Hour Concentrations

SO_2 and TSP 24-hour concentrations were calculated with the CRSTER Model using 6 years of meteorological data based on operating levels of 50, 75, and 100 percent of rated capacity. Results provided by the CRSTER Model for each year of meteorological data processed include a listing of the highest and second-highest concentration at each receptor point. This distinction is important because short-term (3-hour and 24-hour) increments represent increases which can be exceeded once a year. Likewise, short-term ambient standards can be exceeded once a year. To avoid confusion in the following discussion, highest concentrations for any individual year of meteorological data will be referred to as "maximum" concentrations, and second-highest values will be termed "second-high" concentrations. When comparing concentrations computed for different years of data, the modifier "greatest" is used to indicate that the maximum or second-high concentration for one year exceeds the maximum or second-high values for other years.

Second-high SO_2 concentrations for each year of meteorological data are presented in Table 5.1-4 and equivalent TSP results are shown in Table 5.1-5. (The modeling was actually conducted using SO_2

emission rates and the results used to obtain TPS concentrations by applying the ratio of TSP and SO_2 emission rates.) These tables also show the operating level, distance, and direction associated with points of greatest concentration.

From Table 5.1-4, the greatest second-high 24-hour SO_2 concentration is 60 $\mu g/m^3$ which represents 66 percent of the Class II increment. Since six years of meteorological data were used in the analysis, the greatest second-high concentration is the appropriate concentration to compare with the increment. It will also be noted that the distances at which highest concentrations are calculated are very close to the Putnam Site. At greater distances (and in different directions), a lower percentage of the increment would be consumed by Seminole Station emissions. Furthermore, it should be remembered that emissions used for modeling are based on the extremes of the coal characteristics range (lowest heat value and highest sulfur content).

Examination of meteorological conditions associated with calculated concentrations shows that highest 24-hour concentrations result predominantly from a few hours of unstable conditions. This explains why highest concentrations occur near the site and also implies that the results obtained are somewhat conservative since unstable conditions are basically found near the earth's surface and do not often extend to the level of a buoyant plume emitted from a tall stack.

Table 5.1-5 shows that predicted second-high 24-hour TSP concentrations are well below the Class II increment. The greatest second-high concentrations, 2 $\mu g/m^3$, is only 5 percent of the increment. Again, this result is based on emission rates assuming extremes of coal characteristics (lower heat value and highest ash content).

Compliance with PSD Increments - 3-Hour Concentrations

Second-high 3-hour SO_2 concentrations calculated for each of the six years of meteorological data are shown in Table 5.1-6 with the operating level, distance, and direction associated with each concentration. The greatest second-high concentration considered to be most valid is 437 $\mu g/m^3$ at a distance of 1.25 km, a concentration which represents 85 percent of the Class II increment. (See Appendix F for more detailed discussion of 3-hour concentrations.) The variation of second-high concentrations from year to year is fairly large, but in almost every case maximum concentrations are calculated at close receptor points. This can be explained by reference to the meteorological conditions which produce these concentrations. In every case, unstable atmospheric stability conditions, which result in highest values at close distances, are responsible for the results obtained.

Qualifying remarks included in the discussion of 24-hour SO_2 concentrations above also apply to 3-hour SO_2 concentrations. That is, the largest consumption of the increment pertains only to a specific distance and direction and is based on emission derived from the lowest heat value and highest sulfur content of the coal characteristics range.

Compliance with Ambient Air Quality Standards - Annual Average Concentrations

Compliance with annual standards was assessed by modeling all of the sources within the Putnam Site area of interest using the AQDM model. Maximum annual SO_2, TSP, and NO_2 concentrations obtained by this method in comparison with the Florida Ambient Air Quality Standards, are as follows (all concentrations in $\mu g/m^3$):

Pollutant	Maximum Calculated Annual Concentration	Florida Ambient Standard	Distance/Direction from Putnam Site
SO_2	28	60	6 km/170°
TSP	3	60	10 km/10°
NO_2	11	100	14 km/140°

In the case of TSP, comparison of calculated concentrations with the Florida ambient standard is not completely adequate since no background concentration resulting from sources other than those modeled is included in the calculated value. Adding a geometric annual average background value of about 35 $\mu g/m^3$ as suggested by the measured concentrations listed in Table 2.5-3, the total maximum annual average TSP concentration would be about 40 $\mu g/m^3$ (assuming the calculated arithmetic average to be equivalent to a geometric average). Annual average background concentrations of SO_2 and NO_2, as indicated by Tables 2.5-4 and 2.5-5, are very low and need not be added to modeled concentrations since the sources included in the modeling analysis are probably largely responsible for measured background concentrations.

An important point to emphasize in this discussion is that the annual concentrations attributable to Seminole Station emissions alone are practically negligible in comparison with ambient standards. The highest SO_2, NO_2, and TSP concentrations estimated to result from Seminole Station emissions are 5, 3, and 1 $\mu g/m^3$, respectively.

In conclusion, it appears very probably that all annual average standards are currently being achieved and that construction and operation of the Seminole Station will not interfere with maintaining standards compliance.

Compliance with Ambient Air Quality Standards - 24-Hour and 3-Hour Concentrations

In performing a modeling evaluation of short-term concentrations resulting from more than one emission source, it is important that time and space factors be kept consistent. In other words, the interactive effects of each source should be calculated at the same receptor points under the same meteorological conditions.

Based on the location and strength of existing SO_2 and TSP emission sources, the only sources which could have significant interaction with the Seminole Station are Hudson Pulp and Paper Company and Florida Power & Light Company (FP&L). Other exisitng sources are either too far away, have emission rates that are too small, or both.

To assure that time and space considerations are treated consistently, interactions among Seminole, Hudson, and FP&L were computed using a multiple-source variation of the CRSTER Model as described in Appendix F. For reasons discussed in Appendix F, this analysis was performed using 1972 meteorological data, assuming the Seminole Station is operating at 100 percent of rated capacity, and keying on directions within about 30 degrees on either side of the direct angle between the Seminole Station and the other two sources, i.e., directions along which significant short-term interactions could be expected.

The resulting second-high 24-hour and 3-hour SO_2 and 24-hour TSP concentrations from this interaction analysis are presented in Table 5.1-7. The maximum SO_2 concentrations occur near the Seminole Station and are almost entirely due to Seminole emissions. In other words, interaction effects are very minor. In comparison with ambient stardards, the second-high 24-hour SO_2 concentration calculated is 23 percent of the Florida standard (and 16 percent of the national standard), and the second-high 3-hour SO_2 concentration is 40 percent of the Florida (and national) standard.

The second-high 24-hour TSP concentration is predicted to occur in the vicinity of FP&L emission sources. This concentration represents only 4 percent of the Florida ambient standard (and national secondary standard). However, if a background concentraiton of, say, 35 $\mu g/m^3$ were added to the calculated interactive concentration of 5 $\mu g/m^3$, the combined concentration would be 26 percent of the standard.

Impact on Duval County TSP Nonattainment Area

To evaluate the impact of Seminole Station particulate emissions on the Duval County TSP nonattainment area, calculations of 24-hour and annual average concentrations were made using the CRSTER Model at receptor points 50 km north of the Putnam Site. A distance of 50 km was selected since this is the distance to the southern boundary of Duval County and also the generally accepted range limit of the CRSTER Model. Six years of meteorological data were considered, and it was conservatively assumed that the station was operating at 100 percent of the capacity at all times.

For all six years, both the maximum 24-hour and annual average TSP concentrations attributable to Seminole Station emissions were predicted to be less than 1 $\mu g/m^3$. These concentrations are below the level of significant impact recommended by EPA (see Section 2.5.1 for significant impact levels). It is therefore concluded that the Seminole Station will not significantly affect the Duval County TSP nonattainment area if a condition of nonattainment still remains when the Seminole Station begins operation.

Impacts in Relation to Nearest PSD Class I Area

The PSD Class I area nearest the Putnam Site is the Okefenokee National Wilderness Area, located approximately 105 km north-northwest of the Site. Since this distance is beyond the limit of 50 km normally considered appropriate for standard Gaussian models, no attempt was made to calculate concentrations attributable to the Seminole Station directly with in the Okefenokee Class I Area. Instead, calculations were made at a distance of 50 km and compared with applicable Class I increments. These increments are as follows (in $\mu g/m^3$):

	SO_2	TSP
Annual	2	5
24-Hour	5	10
3-Hour	25	--

The 3-hour and 24-hour increments are increases in concentrations which can be exceeded once a year.

Concentrations were calculated with the CRSTER Model at receptors located north-northwest and north of the site (directions 320° through 10°) using all six years of meteorological data. The station was assumed to be operating at 100 percent of rated capacity at all time.

All annual average and 24-hour calculated TSP concentrations are estimated to be less than 1 $\mu g/m^3$ and therefore less than the Class I increment. Annual average SO_2 concentrations are also estimated to be less than 1 $\mu g/m^3$. The greatest second-high 24-hour and 3-hour SO_2 concentrations are 9 and 31 $\mu g/m^3$, respectively, at 50 km from the Putnam Site. (Second-high concentrations are cited because short-term increments can be exceeded once a year.) Since these concentrations are only slightly greater than the Class I increments, no problem is anticipated at a distance of 105 km from the site.

Based on the results of calculations at a distance of 50 km, it is concluded that Seminole Station emissions will have only a minor impact on the Okefenokee PSD Class I Area, an impact which is in compliance with the increases in ambient concentrations allowed in such areas.

5.1.3 Effects of Fugitive Emissions

Fugitive dust emissions may result from coal handling operations, sludge and ash disposal, and onsite traffic even though control measures will be taken to suppress dust formation. Any dust generated will be intermittent and will tend to settle within or very near site boundaries. The impact of fugitive dust emissions on ambient air quality conditions outside plant boundaries is expected to be very slight.

5.1.4 Effects of Sulfur Oxide Emissions on Ambient Sulfate Levels

Gaseous sulfur oxides emitted into the atmosphere can be oxidized to form sulfate aerosols. This conversion process is a complex one which is not well understood or easily evaluated in a quantitative manner. Aside from complexities in the formation of sulfate aerosols, there is also considerable uncertainty concerning the effects of sulfates which are present in the atmosphere. In part because of these uncertainties, no national (or State of Florida) ambient standards for sulfates have been adopted. EPA's current policy on this issue is that research gaps will prevent the establishment of an ambient sulfate standard before a 1981-1982 time frame, and could cause an even longer delay (EPA, 1978). Among the research needs which have been cited are better ambient monitoring programs, a clearer understanding of the relationship between sulfate levels and health and welfare effects, and more research on the transformation and transport mechanisms that affect sulfate concentrations (EPA, 1975). Of particular concern is an improvement in knowledge that will allow more reliable modeling of the effect on ambient sulfate levels of SO_2 emissions from specific sources. Without this understanding, it is extremely difficult to develop a control strategy that will lead to reduced sulfate concentrations if a reduction appears necessary.

Measurements of ambient sulfate levels near Gainesville and Jacksonville over a 3-month period from October through December 1977 indicate that average concentrations were on the order of 5 to 7 $\mu g/m^3$ (Florida Department of Environmental Regulation (DER) and PEDCo Environmental, Inc., 1978; Florida Sulfur Oxides Study, Inc., 1978). In the absence of an ambient standard, it is difficult to place these numbers in perspective, but it can be noted that such values are only about a third of average sulfate concentrations measured at urban stations located in the northeastern U. S. (Altschuller, 1976).

There is evidence that the conversion rate of SO_2 to sulfates in a plume released from an elevated stack is initially fairly slow and then increases at greater downwind distances as ambient air is introduced into the plume (EPA, 1975; Wilson and others, 1977). Factors which affect this conversion process are ambient conditions of relative humidity, temperature, and ozone concentration. Also important are characteristics of the emission source such as presence of catalytic substances in the plume and initial moisture characteristics of the plume. For example, if SO_2 control is achieved through the use of wet scrubbers resulting in a moist plume, SO_2 conversion rates may be accelerated.

In any event, a significant portion of the SO_2 intially released from an emission source will not be converted to sulfates until the plume has been transported a considerable distance downwind. Long-range impacts are further enhanced in that SO_2 to sulfate conversion generally results in the formation of very small aerosols (less than 1 micron in diameter) which can be transported over great distances before being removed from the atmosphere. Tall-stack emission sources may also promote long-range transport in comparison with emissions released from nearer the ground (Altschuller, 1976). SO_2 emitted from a low stack comes into contact with the ground more quickly and is likely to be removed by dry deposition or vegetative uptake before converting to an aerosal sulfate. Emissions from a tall stack, although producing lower ground-level SO_2 concentrations, remain suspended for a longer period of time and are more susceptible to sulfate conversion mechanisms. The possibility of long-range sulfate transport from elevated sources is one of the arguments which has been advanced to explain the observation made in several geographic areas that ambient sulfate concentrations have not declined significantly as local SO_2 emissions decreased (Altschuller, 1976). There is also some indication that sulfates transported from other states may affect ambient sulfate levels in Florida (Winchester and Leslie, 1978). Evidence for this possibility includes an apparent decrease in average sulfate concentrations from Pensacola to Miami, plus the configuration of large-scale air flow trajectories associated with sulfate concentration patterns, both conditions noted during limited duration experimental sulfate measurement period.

Ground-level sulfate impacts resulting from an SO_2 emission source such as the Seminole Station are difficult to assess and must be viewed in terms of both a local and a regional scale. Local sulfate levels could be somewhat more affected by a generating station equipped with a wet scrubbing control system than by an equivalent station without scrubbers; but since the end result of the scrubbing system is to diminish sulfur emissions substantially, impacts on both local and remote areas will be reduced through use of this air emissions control system.

The effects of aerosol sulfates are not well understood. However, it has been determined that a major fraction of the very small particles (0.1 to 1.0 microns) that contribute most to visibility impairment is composed of sulfates (Weiss and others, 1977). Therefore, any sulfate formed due to operation of the Seminole Station could have an effect on prevailing visual range conditions. However, in the southeastern U. S. where high humidity in combination with an abundance of existing natural and anthropogenic aerosol sources already result in visibility restrictions, it is unlikely that the addition of a single new source of sulfur emissions will result in readily perceptible visibility changes.

Another concern is that increased sulfur emissions will lead to the formation of acidic sulfates in rainwater with adverse consequences on surface water bodies, soils, and vegetation. Acid rainfall is another subject which, although undergoing active research, is not well understood either in terms of geographic distribution or effects. Due to the presence of carbonates, "normal" rainfall is already acidic (with a pH of about 5.7), and the focus of acid rainfall concerns is therefore on precipitation more acidic than normal. Measurements of rainfall acidity have not been routinely made over wide areas, but the limited measurements available indicate that lowest pH readings occur in the northeatern U. S. where ambient sulfate levels are higher than in other parts of the country (EPA, 1975). The extent to which emissions from the Seminole Station would cause increased rainfall acidity cannot be accurately calculated.

5.1.5 Effect of Trace Element Releases

Depending on the type of fuel being used, the atmospheric emissions of a coal-fired steam-electric generating station contain varying amounts and types of trace elements. Not all of the trace elements originally present in the coal are emitted. A sizeable fraction of many elements will appear in the ash residue of the combustion process and will be subject to the removal mechanisms applicable to the total ash formed, i.e., deposition as bottom ash and collection by particulate control equipment. Some elements, such as mercury, will vaporize in the combustion zone and can escape in a gaseous form; while others, such as cadmium, lead, and zinc, apparently vaporize and then preferentially adhere to very fine particles which are not collected with the same degree of efficiency as the bulk of the ash material (Klein and others, 1975).

The specific coal supply for the Seminole Station has not yet been determined and therefore it is not possible to estimate coal trace element composition or trace element emission rates. Even if more exact information were available, there would still be the difficulty of interpreting the significance of trace elememt emission releases. As of now there are no Federal or State of Florida ambient air quality standards for trace elements or any National Emission Standards for Hazardous Air Pollutants (NESHAP) specific to coal-fired steam-electric generating stations.

Ground-level concentrations of trace elements resulting from fuel combustion are typically very low, well below the industrial hygiene standards which have been established to control occupational exposure to trace elements. Although occupational standards are established on a different basis and directed toward a somewhat different population than are ambient standards, achieving compliance with occupational standards by a wide margin would indicate that adverse health effects attributable to trace element emissions will be avoided.

Although not in the trace element category, another quantitatively minor class of substances emitted from coal-fired power generating facilities which has caused some concern is polycyclic organic matter (POM). Research is in progress concerning the effects of POM emissions, but it is not now possible to provide a definite statement concerning the impact such emissions from the Seminole Station might have.

5.1.6 Effects on Visibility Conditions

The visibility effects of a coal-fired stream-electric generating station can be divided into three primary categories: (a) plume opacity at the point of release due to direct particulate emissions; (b) plume discoloration at some distance downwind within a relatively intact plume; (c) regional or remote distance visibility impairment.

Plume opacity at the point of release (top of the stack) is regulated by State and Federal New Source Performance Standards (NSPS). Regulated opacity does not include interference of light transmittal due to any water vapor condensation which may result from the use of wet scrubbers. The efficiency of modern particulate removal systems (such as electrostatic precipitators) generally results in meeting opacity standards with little difficulty.

Many of the substances emitted in flue gases undergo chemical transformation in the atmosphere immediately after release. New products formed during this transformation process are referred to as secondary products because they were not originally present, at least to the same extent, in an emitted plume. As a result of secondary products of combustion forming in the atmosphere, plume discoloration can occur within a plume which is still relatively intact. The major contributor to this effect is the conversion of nitric oxide (NO) to nitrogen dioxide (NO_2) which can impart a brownish hue to a plume. Eventually, either additional reactions occur or a plume becomes so diffuse that any discoloration which may have initially developed is no longer apparent. Prediction of the development and degree of discoloration is complicated by an inability to precisely specify either the secondary reactions involved or the rate at which a plume will be dispersed.

Visibility impairment refers to the situation in which the outlines of a plume are no longer detectable but in which both the substances originally emitted and the secondary products resulting from atmospheric chemical conversions contribute to degradation of visibility when a viewer looks toward a remote object or the horizon. Although the primary particulate emissions resulting from coal combustion can have some effect on visibility impairment, the major effect results from the conversion of gaseous sulfur oxides to aerosol sulfates and the subsequent transport of these aerosols over large distances. Widely accepted methods of quantitatively analyzing the visibility impact of a single new emission source have not been established. Factors which complicate such an analysis in the eastern United States are the occurrence of high relative humidities and the existence of substantial background aerosol concentrations resulting from both natural sources and sources related to human activities.

Aside from the great difficulty of accurately predicting and monitoring the formation, transport, and visibility impairment impact of secondary products caused by the emissions of a single source, no regulatory policies have been established to limit impairment. At the direction of Congress, as expressed through the Clean Air Act Amendments of 1977, in which the main concern is with visibility protection in PSD Class I areas, EPA now has underway a research program aimed at developing visibility impact assessment methods and recommending methods to prevent and control visibility impairment. The results of this ambitious task will not be available for general use until sometime in 1979.

Emissions from the Seminole Station will probably have some effect in terms of plume discoloration and visibility impairment at distances remote from the Putnam Site. However, any attempt to estimate the magnitude of these effects would be conjectural. The emission control design features of the Seminole Station will serve as a definite mitigative measure to reduce visibility impacts. Sulfur oxides removal in particular will act to diminish the subsequent formation of aerosol sulfates which are considered to be key ingredients in the impairment of visual range.

TABLE 5.1-1

COAL BURNING AND EMISSION RATES, SEMINOLE PLANT UNITS NO. 1 & NO. 2

Operating Level (Percent of of Rated Capacity)	Maximum Coal Burning Rate (ton/h)	Minimum Coal Burning Rate (ton/h)	Maximum SO_2 Emission Rate (lb/h)	Minimum SO_2 Emission Rate (lb/h)	Maximum TSP Emission Rate (lb/h)	Minimum TSP Emission Rate (lb/h)	Maximum NO_x Emission Rate (lb/h)
50%	257	234	6484	2852	170	89	3396
75%	386	351	9726	4279	255	132	5095
100%	515	468	12968	5705	340	198	6793

Note: Rates shown are for both generating units combined. Maximum and minimum rates are based on the extremes of the coal characteristics range listed below. Maximum and minimum NO_x emission rates are essentially identical; only maximum rates are listed.

Range of Coal Characteristics

Sulfur Content - 1.5 to 3.0 percent
Ash Content - 6 to 10 percent
Heat Content - 11,000 to 12,500 Btu/lb

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TABLE 5.1-2

STACK CONDITIONS,
SEMINOLE PLANT UNITS NO. 1 & NO. 2

Operating Level (Percent or Rated Capacity)	Stack Height (ft)	Stack[a] Diameter (ft)	Exit Velocity (ft/s)	Volumetric Flow Rate (ft^3/min)	Exit Temperature (°F)
50%	675	50.9	13.74	1,681,898	128
75%	675	50.9	20.6	2,522,848	128
100%	675	50.9	27.55	3,363,797	128

[a]Effective stack diameter for combined emissions from both generating units; emissions from each unit actually exit through separate flues within a common stack, each flue bevy 36 ft in diameter.

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TABLE 5.1-3

MAXIMUM PREDICTED ANNUAL AVERAGE CONCENTRATIONS ATTRIBUTABLE TO SEMINOLE PLANT UNITS NO. 1 & NO. 2 EMISSIONS

Maximum SO_2 Concentration ($\mu g/m^3$)	Maximum TSP Concentration ($\mu g/m^3$)	Distance/Direction of Maximum Concentration From Putnam Site
5	<1	45 km/90°

PSD Class II Area Annual Average SO_2 Increment: 20 $\mu g/m^3$

PSD Class II Area Annual Average TSP Increment: 19 $\mu g/m^3$

TABLE 5.1-4

SECOND-HIGH 24-HOUR SULFUR DIOXIDE CONCENTRATIONS
ATTRIBUTABLE TO SEMINOLE PLANT UNITS
NO. 1 & NO. 2 EMISSIONS

Year	Operating Level	Second-High 24-Hour Concentration ($\mu g/m^3$)
1964	100%	53 (1.0 km/20°)[a]
1970	100%	49 (2.5 km/50°)
1971	100%	54 (1.5 km/130°)
1972	100%	60 (1.25 km/60°)
1973	75%	55 (1.25 km/140°)
1974	100%	60 (1.25 km/60°)

PSD Class II Area 24-Hour SO_2 Increment: 91 $\mu g/m^3$

[a]Distance and direction from Putnam Site at which concentration shown is calculated.

TABLE 5.1-5

SECOND-HIGH 24-HOUR PARTICULATE MATTER CONCENTRATIONS ATTRIBUTABLE TO SEMINOLE PLANT UNITS NO. 1 & NO. 2 EMISSIONS

Year	Operating Level	Second-High 24-Hour Concentration ($\mu g/m^3$)
1964	100%	2 (1.0 km/20°)[a]
1970	100%	2 (2.5 km/50°)
1971	100%	2 (1.5 km/130°)
1972	100%	2 (1.25 km/60°)
1973	75%	2 (1.25 km/140°)
1974	100%	2 (1.25 km/60°)

PSD Class II Area 24-Hour TSP Increment: 37 $\mu g/m^3$

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[a]Distance and direction from Putnam Site at which concentration shown is calculated.

TABLE 5.1-6

SECOND-HIGH 3-HOUR SULFUR DIOXIDE CONCENTRATIONS
ATTRIBUTABLE TO SEMINOLE PLANT UNITS
NO. 1 & NO. 2 EMISSIONS

Year	Operating Level	Second-High 3-Hour Concentration ($\mu g/m^3$)
1964	100%	386 (1.25 km/20°)[a]
1970	100%	253 (1.0 km/310°)
1971	75%	391 (1.25 km/130°)
1972	100%	511[b] (319)[c] (1.30 km/40°)
1973	75%	437 (1.25 km/140°)
1974	100%	388 (1.25 km/30°)

PSD Class II Area 3-Hour SO_2 Increment: 512 $\mu g/m^3$

[a]Distance and direction from Putnam Site at which concentration shown is calculated.

[b]The highest concentration for this distance and direction was predicted by CRSTER to be 525 $\mu g/m^3$ and could be rejected due to the occurrence of two consecutive calms coincident with Class A stability in a three-hour period. The indicated second-high concentration (511) would then become the highest concentration with the new second-high becoming considerably lower (see footnote c).

[c]Parenthetical value indicates the greatest second high that results when day 186 of 1972 is excluded from the analysis. The distance and direction of occurrence of this value is 1.5 km at 70° from the Putnam Site.

TABLE 5.1-7

SECOND-HIGH 24-HOUR AND 3-HOUR CONCENTRATIONS RESULTING FROM INTERACTION OF SEMINOLE, HUDSON PULP AND PAPER, AND FLORIDA POWER & LIGHT

Second-High 24-Hour TSP Concentration (μg/m^3)	Grid Center Point	Distance/Direction from Grid Center
5	Florida Power & Light	1.0 km/140°
Second-High 24-Hour SO_2 Concentration (μg/m^3)	**Grid Center Point**	**Distance/Direction from Grid Center**
60[a]	Seminole	1.2 km/ 60°
Second-High 3-Hour SO_2 Concentration (μg/m^3)	**Grid Center Point**	**Distance/Direction from Grid Center**
514[b]	Seminole	1.3 km/ 40°

Florida 24-Hour TSP Ambient Standard: 150 μg/m^3

Florida 24-Hour SO_2 Ambient Standard: 260 μg/m^3

Florida 3-Hour SO_2 Ambient Standard: 1300 μg/m^3

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[a]No contribution from either Hudson Pulp and Paper or Florida Power & Light is expected in this figure.

[b]A negligible contribution of approximately 3 μg/m^3 is expected to have resulted from Hudson Pulp and Paper emission sources.

5.2 HEAT DISSIPATION SYSTEM

5.2.1 Effects of Blowdown Discharge

5.2.1.1 Physical Effects

General

Mineral saturation in the circulating water will be prevented by discharging a portion of the circulating water stream to the St. Johns River (Figure 5.2-1) and replacing that quantity with fresh water. The discharged water, or blowdown (B), is a function of the available makeup water quality and is related to evaporation (Ev) and drift (D) in the following manner (EPA, 1974):

$$B = \frac{Ev - D\ (C-1)}{C-1}$$

In this equation, C equals cycles of concentrations, a dimensionless number that expresses the number of times the concentration of any constituent is multiplied from its original value in the makeup water. (It does not represent the number of passes through the system.) Four cycles of concentration were utilized in the analysis. Facility blowdown rates under four cycles of concentrations are presented in Appendix C, Att. C-1, Table VII. To ensure conservative results the pollutant redistribution assessment utilized the maximum cooling tower blowdown rate shown in the referenced table. If practical, a portion of the cooling tower blowdown will be utilized for scrubber make-up, thus reducing the areal impact of blowdown discharge presented in the following sections.

The blowdown will contain heat and chemical constituents in amounts greater than the ambient levels of the St. Johns River. The thermal impact of the blowdown will vary significantly during a yearly meteorological cycle with the greatest blowdown/ambient temperature differential occurring during the winter and maximum temperatures occurring during the summer. The chemicals in the blowdown will consist primarily of those native to the St. Johns River (Appendix C, Table C-8) but at 4 times the naturally occurring levels. Chlorine and sulfuric acid will be periodically added to the circulating water system to prevent organic growth and scale. In addition, chemical constituents in the ash pond wastewater and in the effluent from the sanitary treatment plant will be mixed with the blowdown before discharging to the St. Johns River. The constituents present in these two waste streams prior to mixing with the blowdown are discussed in Section 5.4.

Consistent with the requirements of the Florida Water Quality Standards (Section 2.3.1.4), the effects of wastes on a receiving stream are determined after reasonable opportunity for mixture of wastes with receiving waters has been allowed.

The investigation of discharge into the St. Johns River utilized separate, though interrelated, calculation procedures described below for the near- and far-field regions. The near-field region is defined as the immediate vicinity of the point of discharge (POD) wherein complex exchanges of momentum and energy take place due to the discharge jet velocity. The far-field region is defined as the portion of the river removed from the POD and the associated turbulent mixing from the discharge jet, yet still subject to effects from the discharge.

Model Identification

The estimate of the near-field impact and dilution was obtained by a well-tested buoyant plume model (Shirazi and Davis, 1974). The far-field impact and circulation patterns were estimated with two computer models developed by Dames & Moore specifically for such applications. Both models are depth-averaged, two-dimensional numerical models suitable for shallow estuarine water bodies. These far-field models are:

1. A hydrodynamic model, TIDAL2, to simulate the flow of the tidally-influenced St. Johns River in the region of the intake and discharge locations.
2. A water quality model, WQUAL2, to simulate the distribution of temperature and dissolved constituents around the POD under selected discharge conditions.

Detailed descriptions of the three models are given in Appendix Section C.4.

Thermal Impacts

An assessment of thermal impacts was conducted for worst-case scenarios of blowdown/ambient incremental water temperature and maximum temperature. As shown in Appendix C, Att. C-1, Table VI, the worst-case incremental temperature between the blowdown and ambient waters is associated with winter conditions and the maximum temperature of both waters is associated with summer conditions.

The assessment of thermal impacts resulting from blowdown discharge was based on two conservative assumptions. First, no temperature reduction of blowdown was assumed from mixing with the chemical and sanitary streams prior to discharge. Second, heat present in the effluent was considered to be a conservative substance, that is, no heat loss to the atmosphere.

The surface area impacted by the thermal discharge is dependent not only on the blowdown and ambient temperatures but also on the ambient flow vector. Under a given steady state flow condition, a plume configuration will form as shown in Figures 5.2-2 and 5.2-3 for winter and summer conditions respectively. From the figures, the location and size of the area affected by the plume will vary depending on the ambient flow conditions. As discussed in the following three sections, the size of the thermal mixing zone for various steady state flow conditions was determined with the near-field model, the fraction of the river cross-section experiencing elevated temperature was assessed with the far-field model, and the total area affected by a mixing zone over a complete tidal cycle was estimated with an interpolation between the near-field/far-field models.

Near-Field Analysis

Design winter conditions were assumed to be an incremental rise of 27°F with an ambient temperature of 59°F. This scenario includes a significant factor of safety for assessment of required winter mixing zones as it requires the simultaneous occurence of the lowest water temperature in 20 years of record and the greatest winter dry bulb/wet bulb temperatures in 34 years of record. In addition the maximum temperature rise across the condensers is expected to be closer to 20°F than 27°F.

Design summer conditions were assumed to be an incremental rise of 3°F with an ambient temperature of 90°F. As above, this scenario is conservative as it involves the simultaneous occurence of extreme recorded summertime river water temperature and meteorological conditions.

From Figures 5.2-2 and 5.2-3 the effluent plume will be oriented with the ambient current and will experience greater spreading under conditions of upstream flow or flow reversals. However, jet inertia force and the attendent turbulent mixing is dissipated more rapidly under upstream flow. The greater the upstream velocity, the closer to the POD is the elimination of the jet inertia forces. For example, during an upstream velocity of 0.2 fps, zero jet velocity occurs 300 feet from the POD. Under the extreme condition of an upstream flow velocity of 1.0 fps, the jet inertia forces are reduced to zero within 35 feet of the POD. Spreading of the plume after the jet velocity dissipates is governed by the slower mechanisms of diffusion and buoyancy which are assessed with the far-field models.

The average upstream velocity of approximately 0.2 fps was used to determine the pattern of maximum steady state spreading of various isotherms in the near-field. The maximum areas encompassed by different isotherms during both summer and winter design temperatures and an upstream velocity of 0.2 fps are given in Table 5.2-1. Additional information concerning the near-field thermal assessment is provided in Appendix C, Section C.3.4.

Far-Field Analysis

Once the jet inertia forces are reduced to zero, the dispersion of the effluent plume was assessed with the far-field models. The far-field analysis assessed the plant wastewater dispersion during a seven-day period of near oscillatory flow in the St. Johns River (7-day MAF; Section 2.3.1.1) with a temperature differential equivalent to the maximum between average monthly ambient and blowdown temperatures (Appendix C, Att. C-1, Table VI). This differential of 12°F with an ambient of 63°F was determined to be the most realistic worst-case design condition for a longterm (7-days) thermal assessment. Assessment of summer conditions was not conducted as the 3°F increment between ambient and blowdown temperatures would be undetectable by the far-field WQUAL2 simulation.

As shown in Figure 5.2-4 the wastewater temperature is computed to be less than 0.1°F above ambient within 500 feet of the POD. With an assumed intake/discharge structure separation of 450 feet, the build up of heat at the intake will be negligible. Because of conservative assumptions stated earlier, temperatures would actually be lower than calculated due to heat exchange between the heated plume and the atmosphere. In addition, 0.1°F represents the maximum ΔT occurring at the intake during the 7-day MAF. This maximum would persist in the vicinity of the intake for a limited portion of the tidal cycle. During the major portion of the tidal cycle the ΔT at the intake would be less than 0.1°F.

Based on the far-field analysis, the blowdown discharge will comply with the Florida Water Quality Standard which limits thermal plume dimensions to no more than one-third of a stream's surface width and one-fourth of its cross section. From Figure 5.2-3, the maximum temperature outside of the one-third surface width is only 0.05°F above ambient. This increase is less than one-third the accuracy of 0.1°C (0.16°F) of field measurements of the St. Johns River temperature data base.

<u>Total Area of Thermal Impact</u>

An estimate was obtained of the total area effected by a thermal mixing zone over a complete tidal cycle by assuming that the thermal component is a conservative substance and applying the dimensionless near-field/far-field interpolation model described in Section C.3.5 of Appendix C. For a given ratio of excess constituent concentration versus initial excess, the model provides the total area that may experience that excess constituent ratio or greater during at least a portion of the tidal cycle.

The results of the assessment are provided in Table 5.2-1 and Figure 5.2-7.

Chemical Constituents

Apart from chemical additives, cooling tower blowdown will contain the same dissolved chemicals native to the St. Johns River (Appendix C, Table C-8) but at 4 times the naturally occurring concentrations. In addition, chemical constituents present in the wastewater from the chemical and sanitary treatment facilities (Figure 3.4-1) will mix with the blowdown before it is discharged into the St. Johns River. The range of total concentrations of the various chemical constituents in the wastewater reaching the St. Johns are shown in Appendix C, Att. C-1, pages II-6 and II-7.

Near-Field Analysis

The increase in concentration of chemical constituents over ambient conditions under different ambient velocities in the near-field is shown in Figure 5.2-5 in terms of the ratio between the effluent plume's original excess concentration and the remaining excess concentration. The ratio is shown with an isopleth representing a line of equal excess concentration along the plume trajectory. As explained under the preceding section, an upstream velocity of approximately 0.2 fps may be used to determine the pattern of maximum spreading of the wastewater plume in the immediate vicinity of the POD.

Far-Field Analysis

After the jet inertia forces are reduced to zero, the dilution and dispersion of the effluent stream was defined with the far-field analysis for the design flow regime or 7-day MAF. The excess concentration of each chemical constituent is diluted to 2.4 percent of its initial value within 500 feet of the POD (Figure 5.2-6).

Chemical Constituent Mixing Zones

The required mixing zones for each constituent were defined as being the total area experiencing constituent concentrations in excess of state standards. The mixing zones for those constituents which may be discharged at concentrations in excess of state standards were estimated with an interpolation model of the near-field/far-field assessments (see Appendix C, Section C.3.5).

Table 5.2-2 shows the estimated mixing zones required under given steady state ambient constituent concentrations. Except for lead, cadmium, mercury, zinc and oil and grease the ambient concentrations represent the maximum concentrations measured at the USGS Palatka water quality station (EPA, 1978). From Table 2.3-1, the maximum measured ambient chemical concentrations of the five constituents listed above exceed the limits of the Florida DER criteria. As a result, under certain ambient concentrations the wastewater chemical constituents cannot be diluted to concentrations within the criteria. However, generally, the ambient concentrations of the metals are well below the state standards. For oil and grease the data base of only two measurements is too limited to determine the general background conditions. The ambient concentrations shown in Table 5.2-2 for the five constituents are the concentrations at which the facility effluent will be diluted to within state standards within a 31.0 acre mixing zone.

Constituent Buildup at Intake

Assuming the intake point will be at the edge of the maximum allowable 31.0 acre mixing zone (Appendix C, Section C.3.6) the maximum buildup of constituents at the intake should be less than a 7 percent increase over ambient concentrations. The 7 percent value is based on the assumption that an oscillatory flow coupled with a steady on-shore wind persists for a period of time equivalent to four complete cycles of recirculating water replacement. The build-up above seven percent becomes insignificant for greater periods of time. The analysis is described in Appendix C Section C.3.7 and the results summarized in Table 5.2-3.

The buildup indicated in Table 5.2-3 is an upper limit value that is highly unlikely to occur. No evidence exists from the meteorological data that an on-shore wind would persist for the several days necessary for a four-fold replacement of recirculating water. The likelihood of such a meteorological conditions if it did exist occurring along with the MAF is quite remote.

Turbidity, DO, pH

Other water quality parameters to which numerical Florida Water Quality Standards apply include turbudity, dissolved oxygen (DO), and pH. Since turbidity is measured in Jackson Turbidity units (JTU) which are not equivalent to dissolved chemical concentrations, the near- and far-field analysis may not be applied to compute the increase in turbidity resulting from blowdown discharge. A slight increase in turbidity in the St.Johns River may occur, but the resulting impacts were not quantified and will probably be negligible.

With regard to DO, cooling tower blowdown will probably be at near-saturated DO levels due to the continuous aeration of the recirculation water. The maximum blowdown temperture of 93°F would result in the minimum DO concentration of 7.5 mg/liter at saturation. The 5.0 mg/liter of BOD_5 in the sanitary wastewater will be diluted to .018 mg/l in the combined wastewater stream and should produce only slight reduction in the DO. Even if the sanitary and chemical waste streams had no DO and all the BOD_5 was satisfied in the combined waste stream prior to discharge, the concentration of DO would still be greater than 7.0 mg/liter. This value is greater than the minimum allowable ambient DO concentration of 5.0 mg/liter, blowdown discharge should not cause DO concentrations in the St. Johns to fall below the Florida limit.

With regard to pH, the analysis methodology discussed in Appendix C, Section C.3.3 was used to compute the pH of the combined wastewater stream. The pH of the blowdown will be within the range of 7.0 to 7.5. After mixing with other wastewater streams, it should be from 7.5 to 6.8. As these extremes are within the Florida limits of 6.0 to 8.5, the wastewater stream should have no adverse impact on pH levels in the St. Johns River.

Chemical Additives

In order to control biological growths in the condenser that would reduce unit efficiency, chlorine will be added intermittently. Only enough chlorine to provide a residual of 0.5 to 1.0 mg/liter total chlorine at the condenser discharge will be used. Four to six applications per day for a period of 15-30 minutes will be used. In order to comply with 40 CFR 423, the cooling tower blowdown valves will be closed during chlorine application, and for a sufficient time afterwards, to limit chlorine in the blowdown water to an average of less than 0.2 mg/liter for a total period not to exceed 2 hours per day per cooling tower.

From Table 5.2-2, the calculated chlorine concentration in the river resulting from the discharge of the cooling tower blowdown would be less than 0.01 mg/liter within an area of 3.0 acres.

The water treatment to be employed at the plant to control scale formation will be sulfuric acid. Calcium bicarbonate is converted to the more stable and more soluble calcium sulfate. The application of sulfuric acid will increase the sulfate concentration of the blowdown stream. The methodology used to determine the resulting sulfate concentraion is presented in Appendix C, Section C.3.2. The results indicate a maximum total sulfate concentration discharged to the St. Johns of 940 mg/liter.

Discharge Criteria

Standards of performance to control the quantity or quality of pollutants discharged as a result of cooling tower blowdown are contained in "Effluent Guidelines and Standards for Steam Electric Power Generating Point Sources" (40 CFR 423). These guidelines include criteria for the following discharges: chlorine, corrosion inhibition, and water temperature. These criteria for cooling tower blowdown will be met by the design and operation of the plant's recirculating cooling system.

5.2.1.2 Biological Impacts

The blowdown discharge imparts a thermal and a chemical change on the aquatic environment, either of which may influence the biota of the St. Johns River.

Changes in temperature may prescribe localized changes in an aquatic community. Thermal gradients produced by cooling tower blowdown, may cause some aquatic organisms to selectively avoid or to be attracted to affected areas. Other possible effects, associated with increases in temperature above ambient, include changes in community structure, to include shifts towards nuisance organisms; and decrease in dissolved oxygen, resulting from increased organic decomposition and decreased oxygen solubility (EPA, 1974). None of these effects, however, are likely to occur as a result of the small fraction of the river influenced and the rapid rate of dilution with river water.

The maximum ΔT between ambient and the blowdown discharge during plant operation in the summer will be 18° (10°C); winter blowdown, produces a ΔT of 27°F (15°C) over ambient. These may impact the aquatic community in several ways.

Although more data are generally available on fish than on other aquatic organisms, some generalizations on thermal influences can be made that apply to these other major aquatic groups.

The effects of temperature increases in phytoplankton and zooplankton will be primarily to enhance metabolic rate, and thereby, may promote growth and reproduction. Churchill and Wojtalik (1969) and Heink (1969) reported warm discharges could sufficiently stimulate reproduction of some plankters to replace their numbers within a few hours. Some planktonic organisms may be damaged by higher temperatures. However, the fraction of the population affected and the length of time are so small as to minimize the effect. The thermal plume, therefore, would have little adverse effect on the plankton passing through it. Higher temperatures, also may have the effect of increasing productivity of nuisance organisms, primarily the blue-green algae. However, Cairns (1956) suggested that these algae require temperatures over 95°F (35°C) for such a shift in dominance to occur. This is higher than any thermal discharges anticipated for the Seminole Station.

Benthic organisms have also been studied very little with respect to thermal responses. In general, their numbers and distribution decreases with increases in water temperature (Federal Water Pollution Control Administration [FWPCA], 1967). However, a balanced benthic population can still tolerate temperatures up to about 90°F (32°C) (FWPCA, 1967). This temperature is exceeded slightly during summer months, but the direction of the discharge away from the bottom and rapid mixing with the river water should prevent thermal impacts on the benthic community. Aquatic macrophytes exhibit valued resources to increase temperatures but as with benthic invertebrates, the rapid mixing of effluent with the river water will prevent any significant alterations in macrophyte communities. In the immediate vicinity of the discharge, there may be shifts in community structure to more tolerant species. Macrophytes, however often vary in their growth patterns, and major shifts in community structure may occur for a variety of reasons, other than from the thermal effects (Hynes, 1972).

Fish generally show a behavioral response to thermal discharge either by moving rapidly through the plume or migrating along the discharge zone to temperature ranges for which they are best adapted. There are two primary thermal effects that are important in assessing impacts on fish communities. One of these effects is described by the T obtained in the summer where thermal additions from blowdown discharge may elevate temperatures above the tolerance unit for some species. The area impacted will be most pronounced during incoming tides (Figure C-9). Under "worst case" conditions, a maximum temperature at the POD will be 93°F (33.9°C). However, under the tidal flow conditions defined as "steady state" (Section 5.2.1.1), the temperature will be reduced to 91°F (32.8°C) within an area of 200 square feet. The mixing with ambient, at a maximum of 90°F (32.2°C), will reduce the temperature to 91°F (32.8°C), and at the boundary of a total area of 240 square feet, this will be further reduced to 90.5°F (32.5°C).

The increase in temperature provided by the blowdown will not in itself produce stress for most of these aquatic vertebrates (NAS, 1974). The movement of fish through a thermal plume, however, can produce stress if a substantial difference exists between the plume and ambient temperature. Organisms that preferentially stay in these warmer waters are vulnerable to stress during interruption of plant operation. The maximum ΔT under "worst case" conditions (Section 5.2.1.1, Thermal Impacts) is 27°F (15°C), although rapid dilution occurs and the temperature quickly returns to ambient. Thus, under steady state tidal flow (Section 5.2.1.1) in an area occupying 8 square feet from the POD, the maximum ΔT is 15°F (8°C) and at the limits of an area encompassing 155 square feet from POD, the ΔT is only 5°F (2.5°C). There are inadequate data to clearly demonstrate the variance in temperature above ambient necessary to elicit stress (NAS, 1974). Figure 5.2-8, however, illustrates EPA recommendations for allowable winter time differences. This shows that for an ambient minimum temperature of 59°F (15°C), a winter discharge temperature would be allowed that is well above the maximum of 86°F (30°C) projected for this station. Because of the small proportion of the river cross section affected by the plume, however, most fish will rarely incur any ΔT resulting from this blowdown discharge.

Chemical Effects

Chemicals in the blowdown will contain a mixture of the constituents of the St. Johns River (at 4 times concentration), residual chlorine, additional sulfate, chemical and sanitary treatment plant effluent. The effects of these substances on aquatic organisms depend upon several factors:

1. The location and mobility of the organisms. Those located nearest the discharge and unable to move, such as benthic macroinvertebrates, may be subjected to the highest concentrations and be stressed. Organisms capable of moving away from the effluent plume will avoid harmful concentrations. Since the plume will be directed away from the bottom, however, there should also be minimal impact upon benthic organisms.

2. The time that organisms are in contact with effluent. The prolonged or chronic effects of certain chemicals may produce adverse responses in aquatic organisms. However, planctonic forms will be rapidly carried into more dilute regions of the

river, and larger nektonic species can move away from the plume.

Generally, the response of an aquatic organism to varying concentrations of specific chemicals is determined by a 96-hour, LC_{50} (lethal concentrations for 50 percent of individuals in 96 hours) under defined laboratory conditions. However, the LC_{50} for relatively few species has been determined, and the laboratory reponses may not mimic field conditions. Nevertheless, the maximum recommended concentrations of selected chemicals are noted in Table 5.2-5. These values were not all obtained by a 96-hour, LC_{50} analysis, but they do represent the best estimates currently avaiable of concentrations above which detrimental effects may occur.

Of the chemical constituents related to the effluent, all will be below the recommended units at the boundary of the 31-acre mixing zone when the ambient values are the same as shown in Appendix C, Table C-17. The paucity of bioassay data for organisms likely to encounter the plume makes it impossible to predict overall impacts on specific organisms. Those species present in the St. Johns River may have a preadapted tolerance for these high levels, since the background concentrations were sometimes above recommended levels. Long term impacts, however, from bioconcentration and bioamplification may impose reduction in productivity and reduce the numbers of individuals. The majority of aquatic organisms, however, will not pass through these higher concentrations, however, since the area where these levels occur encompass a small fraction of the river cross-section. Additionally, rapid mixing of the discharge with the river will rapidly reduce these chemicals to ambient concentrations.

5.2.2 Effects of Intake Structure Location, Design, and Capacity

5.2.2.1 Effect of Water Use

The impact on overall St. Johns River Basin water resources of the withdrawal of cooling tower makeup is considered negligible. The rationale for this determination is based on a comparison of withdrawal rate and the volume of unused freshwater available in the St. Johns River.

28.4 MGD

As documented in Section 2.3.1.1, two characteristics of the river tend to make it an enormous source of suitable water for makeup. First, the average flow is 7,613 cfs compared to a maximum intake rate of 44 cfs. Thus, the maximum plant use will be less than one-half of one percent of the river flow. Second, the estuarine nature of the river provides a large storage capacity in the channel. The river functions similar to a reservoir, providing a large volume of freshwater during periods of low basin runoff.

5.2.2.2 Biological Aspects of 316(B) Intake & Siting

The Development Document (EPA, 1976) sets forth certain recommendations for the design and location of cooling water intakes. In the intake design and siting of the proposed Seminole Plant Units No. 1 and No. 2, the applicant and its consultants have made every effort to address these and provide a design and siting which may correspond to Best Available Technology.

There are basically two ways in which a cooling water intake can adversely affect aquatic organisms. The first is through entrapment or impingement onto water screening devices. The second is entrainment into the cooling water system of the plant.

Entrainment will potentially impact all free floating organisms small enough to pass through the intake screening system. Entrainable organisms will potentially include phytoplankton, zooplankton, some smaller macroinvertebrates, fish eggs, larvae, and some juveniles. The size of organism impacted will be controlled by the intake screening openings. The numbers of organisms affected will depend upon the volume of water withdrawn, location of the intake, area of intake, hydraulic influence, and abundance of the organisms.

In general, the impact to the smaller non-screenable organisms will depend largely on their abundance and the volume of water withdrawn. Where water volumes withdrawn are low, the potential for impact is also low and roughly proportional to the percentage withdrawn from the source water body.

Capacity

The volume of cooling water flow is generally related to the potential for entrainment impact. Reduction of cooling water flow is recognized as an effective means (EPA, 1976) for reducing the potential for entrainment. The proposed Seminole Plant Units No. 1 and No. 2 will utilize close-cycle cooling in order to reduce cooling water intake flows. The lessening of intake flow will result in a reduction in the potential number of organisms encountering the intake and hence a reduction in the number of organisms potentially impactable by either entrainment or impingement (EPA, 1977). As noted in Section 5.2.2.1, the proposed intake cooling water flow represents a very small percentage of the river flow; therefore, only a very small percentage of organisms present will be even potentially available for any potential impact by the proposed plant.

Velocity

The maintenance of low intake velocities can prevent the impingement or entrapment of organisms or allow the escape and survival of any which become entrapped (EPA, 1977). Lower velocities also effectively reduce the area influenced by the intake. The design objective for the proposed Seminole Plant Units No. 1 and No. 2 intake will be to maintain a maximum approach velocity of 0.5 feet per second; this will be achieved by designing the screens to pass the maximum expected inflow rate at 0.5 feet per second maximum (net) velocity through the screens. The Development Document (EPA, 1976) notes increased impingements when intake approach velocities are greater than 0.8 foot per second and notes the desirability of intake approach velocities no greater than 0.5 foot per second. As noted in the Development Document, approach velocities are always lower than velocities through the screens (new velocities). Approach velocities at the proposed Seminole Plant Units No. 1 and No. 2 will, therefore, be substantially less than those discussed in the Development Document and as discussed by U. S. Fish and Wildlife Service (1974) for protection of fish. Low intake velocities should substantially reduce any potential for adverse impact in fish and macroinvertebrate populations. In particular, neither healthy adult fish nor older juveniles should become entrapped on the screens.

Intake Location

Three potential intake corridors (Section 9.3.2) were selected as potential sites for intake locations. Aquatic sampling (Section 2.7.2) was performed at each of these sites and results presented (Appendix B, Tables B-29 to B-35, B-37). These sites and data were reviewed for the purpose of siting the intake to minimize potential adverse impacts.

In examination of all fish captured for the three corridors presented in Section 2.7.2, Tables B-29 through B-35, the lowest number of captures by all techniques was found at Corridor A (Transect B). Captures of food, game, and commercial species were also examined. These species are of great interest because of their importance in the food web and to man. For these species, the lowest numbers of captures were also made at Corridor A. Due to particular interest in the commercially and recreationally important anadromous species (American shad and striped bass) captures of all adult, juvenile, and larval fish were examined. Only one American shad was collected during this program upstream of all three corridors at the control transect. No adult striped bass were collected during the sampling program; however, some captures of striped bass were made at Corridors B and C (Transects C and D) during the larval net sampling program. Densities collected were low, between 0.4 and 0.6 fish per 100 cubic meters.

Due to the extremely low net intake velocity which will be used at the propsoed plant, concern for intake placement to protect later life stage fish and macroinvertebrates is not as important as placement to avoid entrainment of younger life stages. A fish sampling program aimed at larvae, eggs, and juveniles was conducted and results reported in Section 2.7.2.3.3. Examination of the capture data reveals that the lowest overall total captures were found at Corridor A. These were dominated by the bay anchovy, a common forage species, which accounted for between 88 and 99 percent of the larval net captures at Corridor A. The bay anchovy is extremely abundant in the St. Johns River (Section 2.7.2.3.3), and the potential loss will be kept very low due to intake capacity, design, velocity, and placement.

The presence of macrophytes in an area within 250 feet of the shoreline has been noted, and a study is underway to determine their significance.

Due to the above considerations, and taking cognizance of recommendations by EPA (1977) to avoid areas of high biological value, Corridor A was selected as the intake site most likely to minimize potential adverse impacts.

The placement of the intake at Corridor A relative to the shoreline was also examined. Since the intake is unlikely to have an adverse impact on later life stages of fish, examination was aimed principally at earlier life stages. No significant difference between offshore and nearshore collections of younger life stages could be detected. Variations of densities of macrobenthos between nearshore and offshore areas did not show consistently significant differences. Although the presence of a depauperate aquatic habitat nearshore makes it less likely to be utilized than offshore areas, there is no strong biological preference for either area at Corridor A.

Field Test to Determine Screen-opening Size

The most desirable intake for protection of biota is one that would have the minimal potential adverse impact. Ideally, this would consist of an intake with fine enough screening to prevent the entrainment of eggs, larvae, juveniles, and adults of all species, and a small enough intake velocity so that organisms could escape from the screens. Such a design would also have to be practical for both an engineering and cost viewpoint as recognized by EPA (1976).

The proposed design uses fine mesh wedge-wire screening to prevent entrainment of various sized organisms and low intake (net) velocities to allow organisms to escape the screens. It is SECI's proposed plan to use the smallest opening wedge-wire screens that can be utilized under engineering feasibility criteria (technology available) for this purpose. The exact size of the screens will be determined by an *in situ* engineering feasibility study. The biological aspects of the test are discussed in detail in a Plan of Study, Aquatic Biology Program to Monitor *in situ* Intake Screen Testing (the Plan of Study is contained in Appendix B). The Plan of Study was reviewed by the U. S. Fish and Wildlife Service (National Power Plant Team), the U. S. Environmental Protection Agency, the Florida Department of Environmental Regulation, and the Florida Game and Freshwater Fish Commission before it was finalized. The work described in the Plan was begun in January 1979.

5.2.3 Atmospheric Effects of Cooling Towers

Emissions from natural draft cooling towers occur in essentially two forms. The first, and by far the larger, is water vapor emitted as the result of evaporative cooling processes. Evaporation losses from the two natural draft towers to be operated at the Putnam Site are estimated to be about 8,250 gallons per minute (gpm). This water vapor may later condense to liquid droplets after leaving the towers, but such droplets will be in an essentially pure form and will contribute nothing to ambient solid particulate concentrations.

The second type of emissions from cooling towers consists of very small droplets referred to as drift. Modern towers are equipped with efficient drift eliminators that limit drift loss to a very small fraction of the circulating water flow. The drift emission rate for the Seminole Station towers is estimated to be only 0.005 percent of the circulating flow or 29 gpm. The significance of drift losses from an ambient air quality standpoint is that drift droplets normally contain dissolved solids which, following droplet evaporation and deposition, can add to ambient ground-level particulate concentrations.

A conservative method of estimating the solids fraction of drift emissions is to assume that the total dissolved and suspended solids content of drift droplets is equivalent to levels found in cooling tower blowdown discharges. Blowdown from the Seminole towers is expected to contain a maximum of 3740 mg/liter total dissolved solids and a maximum of 184 mg/liter total suspended solids, for a total of 3924 mg/liter.

Combined drift emissions from the two natural draft towers to be operated at the Putnam Site is estimated to be 39,000 gpd. Combining the 3924 mg/liter solids content with the 39,000 gpd total drift emissions from both towers, it can be conservatively estimated that the total maximum solids equivalent emission rate from both cooling towers is 1,286 lb/day (39,000 gal/day x 8.4 lb/gal x 0.003924 solids fraction). This is equivalent to 54 lb/hour. In comparison, particulate emissions resulting from combustion of high ash coal with both generating units in operation at rated capacity is expected to be 264 lb/hour, nearly 5 times greater than maximum cooling tower emissions.

Modeling of particulate emissions from coal combustion has indicated that the impact of such emission on ground-level concentrations will be only a small percentage of the standards established to regulate these concentrations. While an evaluation of drift ground-level impact cannot be accurately made, some perspective can be gained by comparing stack particulate emissions with cooling tower drift.

The height of release and plume rise of cooling tower emissions differ from those of the boiler stacks. More importantly, liquid droplets released from cooling towers behave differently than fly ash particles emitted from a stack, and therefore, the same modeling techniques are not appropriate for both types of emissions. Fly ash particles are assumed to be small enough to behave in accordance with the diffusion properties of a gas. Drift droplets, on the other hand, have a much wider size distribution. A considerable percentage of these droplets are large enough to have an appreciable settling velocity, and 1 their paths can be assessed initially by a trajectory analysis until droplet size is reduced by evaporation at which time something on the order of the Gaussian diffusion analysis becomes more appropriate. The end result of this complex behavior is that maximum ground-level particulate concentrations traceable to cooling tower emissions tend to occur at closer distances than those from tall-stack fly ash emissions. The relatively small quantity of solids equivalent emissions from the Seminole cooling towers (less than 150 tons per year based on an average blowdown discharge solids content of 2344 mg/liter and an annual average station operating level on the order of 70 percnet of rates capacity), to be released from source which are approximately 450 ft in height and at least 1400 feet from the nearest site boundary, suggest that ground-level impacts beyond site boundaries will be minor.

With regard to the interaction or intermingling of cooling tower and stack plumes, the first point to note is that complete intermingling will not occur continuously. Because of such factors as directional orientation, separation distance, structure height difference, and plume rise difference, there will frequently be only partial interaction. Also, the effect when interaction does occur is uncertain. Conceivably, the mixture of stack SO_2 emissions with a moist cooling tower plume can lead to accelerated formation of acidic aerosols. Whether or not these aerosols reach the ground any earlier because of plume mixture is not evident. Further, the SO_2 content of Seminole Station stack emissions will be greatly depleted after passage through wet scrubbers. These scrubbers will create a moist environment for stack emissions independent of any interaction with cooling tower plumes. Therefore, any stack/cooling tower interaction which occurs is not expected to add appreciably to impacts which would occur in the absence of this interaction.

5.2.4 Visibility Effects of Cooling Towers

Because of the tremendous quantity of water vapor released from large generating station cooling towers, there is a potential for the formation of large visible plumes. If the saturation deficit of the atmosphere is low, then the water emitted from a cooling tower can supply the deficit and a visible plume will result. Aside from aesthetic considerations, the only potential impact that a visible condensed water vapor plume poses is one of safety. A visible plume which reaches the ground beyond station boundaries can obstruct visibility and create a hazard.

A general conclusion drawn from cooling tower plume visibility studies is that tall natural draft towers produce a longer visible plume than do shorter mechanical draft towers, but on only rare occasions does a visible plume from a tall natural draft tower reach the ground (Roffman, 1975). The release point of evaporative emissions from a natural draft tower is 450 feet above ground level, and release of the latent heat of vaporization as condensation occurs imparts a buoyancy force which causes the plume to rise well above the point of release. One effect of this is that the plume will often rise above any shallow surface - based on inversion layers which may be present, and will not be trapped near the ground.

The infrequent occurrence of a visible plume from a tall natural draft cooling tower reaching ground level is cited by Hosler (1972) in his review of a study made at the Keystone Plant in Pennsylvania. During a two-year period of intermittent measurements, only one case of a plume reaching ground level was observed. Similarly, observations made in England near large natural draft cooling towers revealed no cases of fog (visible plume) at ground level which could be attributed to evaporative emissions from cooling towers (Moore, 1975).

In summary, the two natural draft cooling towers to be operated at the Seminole Station will be the most noticeable features of the installation, because of the size of these structures and because of evaporative emissions which will frequently produce visible plumes. The length of these plumes will at times extend past site boundaries, but plume release height and buoyancy will be such that the potential for creation of an offsite ground-level traffic hazard due to obstruction of visibility is very minor.

TABLE 5.2-1

THERMAL MIXING ZONES AREAS[a]

SUMMER CONDITIONS		WINTER CONDITIONS	
ISOTHERM °F	MAXIMUM AREA (sq. ft.)	ISOTHERM T°F	MAXIMUM AREA (sq. ft.)
92.0	7.	15	8.
91.5	11.	10	26.
91.0	38.	5	155.
90.5	240.	2.5	1000.
90.1	16000.[b]	1.0	16000.[d]
MAXIMUM TOTAL AREA IMPACTED OVER COMPLETE TIDAL CYCLE[d]			
92.0	261	15.0	655
91.5	1000	10.0	2440
91.0	3223	5.0	11000
90.5	13500	2.5	43560
90.1	413800	1.0	326700

[a]Based on near-field modeling assessment.

[b]Corresponds to isotherm C, Figure 5.2-3.

[c]Corresponds to isotherm C, Figure 5.2-2.

[d]Based on near-field/far-field interpolation model discussed in Appendix C, Section C.3.5. See Figure 5.2-6.

TABLE 5.2-2

MIXING ZONES

Parameter	Units	Ambient Concentration	Mising Zone
Iron	mg/l	.56	0.5
Chlorine			
1 unit	mg/l	0	23.0
2 units	mg/l	0	3.0
Specific Conductance	μmhos/cm	510	4.0
Ammonia (un-ionized)	μg/l	11.4	10.5
Aluminum	mg/l	.15	19.2
Copper	μg/l	10.0	1.0
Cadmium	μg/l	.87	31.0
Lead	μg/l	28.	31.0
Mercury	μg/l	.18	31.0
Zinc	μg/l	25.	31.0
Oil & Grease	mg/l	4.67	31.0
Phenolic Compounds	μg/l	.28	50 sq. ft.
Selenium	μg/l	10.0	900 sq. ft.

[a]Area in acres except where noted.

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TABLE 5.2-3

CHEMICAL CONSTITUENTS
MAXIMUM BUILDUP AT INTAKE[1]

Parameter	Units	Ambient Concentration[2]	Maximum Buildup[3]
Iron	mg/l	.56	.60
Copper	μg/l	10.0	10.7
Specific Conductance	μmhos/cm	510.	545.
Ammonia	μg/l	11.4	12.2
Aluminum	mg/l	.15	.16
Selenium	μg/l	10.0	10.7
Cadmium	μg/l	0.87	.934
Lead	μg/l	28.	30.08
Mercury	μg/l	.18	.193
Zinc	μg/l	25.	26.85
Oil & Grease	mg/l	4.67	5.02

[1]Values represent maximum buildup of constituents at the intake during a period of upstream flow lasting longer than several intake/outfall recirculation cycles.

[2]Ambient values from Table 5.2-2.

[3]Upper limit of buildup of conservative substances at the intake.

TABLE 5.2-4

Recommended Concentration Limits for Selected Parameters to Provide Minimal Effect on Aquatic Organisms

Parameter	Recommended Maximum Concentration	Remarks	Reference
Aluminum	100 μg/liter		EPA (1973)
Ammonia	20 μg/liter	Toxicity decreases with decrease in pH on temperature.	EPA (1976) DER (1978)
Arsenic	50 μg/liter		EPA (1976) DER (1978)
Cadmium	1.2 μg/liter	Toxicity depends on hardness and alkalinity of water. Less toxic in hard water and/or water of high alkalinity.	EPA (1976) DER (1978)
Chromium	100 μg/liter		EPA (1976)
Copper	30 μg/liter	More toxic to algae and mollusks than to other aquatic organisms.	EPA (1976)
Iron	1.0 μg/liter	Field data suggest adverse effects at concentrations considerably above 1000 μg/liter.	EPA (1976) DER (1978)
Lead	30 μg/liter	Toxicity depends on hardness and alkalinity of water. Less toxic in hard water and/or water of high alkalinity.	EPA (1976) DER (1978)
Mercury	0.02 μg/liter		EPA (1976) DER 1978
Nickel	100 μg/liter		EPA (1976)
Oil & Grease	15 mg/liter	Toxicity depends upon specific component.	EPA (1976)

TABLE 5.2-4 (Continued)

Parameter	Recommended Maximum Concentration	Remarks	Reference
Residual Chlorine	10 μg/liter	Aquatic organisms tolerate short term exposure to higher concentrations.	EPA (1976) DER (1978)
Selenium	25 μg/liter		DER (1978)
Zinc	30 μg/liter	Influent of pH and other factors preclude setting a general limit for all aquatic organisms. Chronic toxicity reported at concentrations over 100 μg/liter.	Becker, and others, (1973)

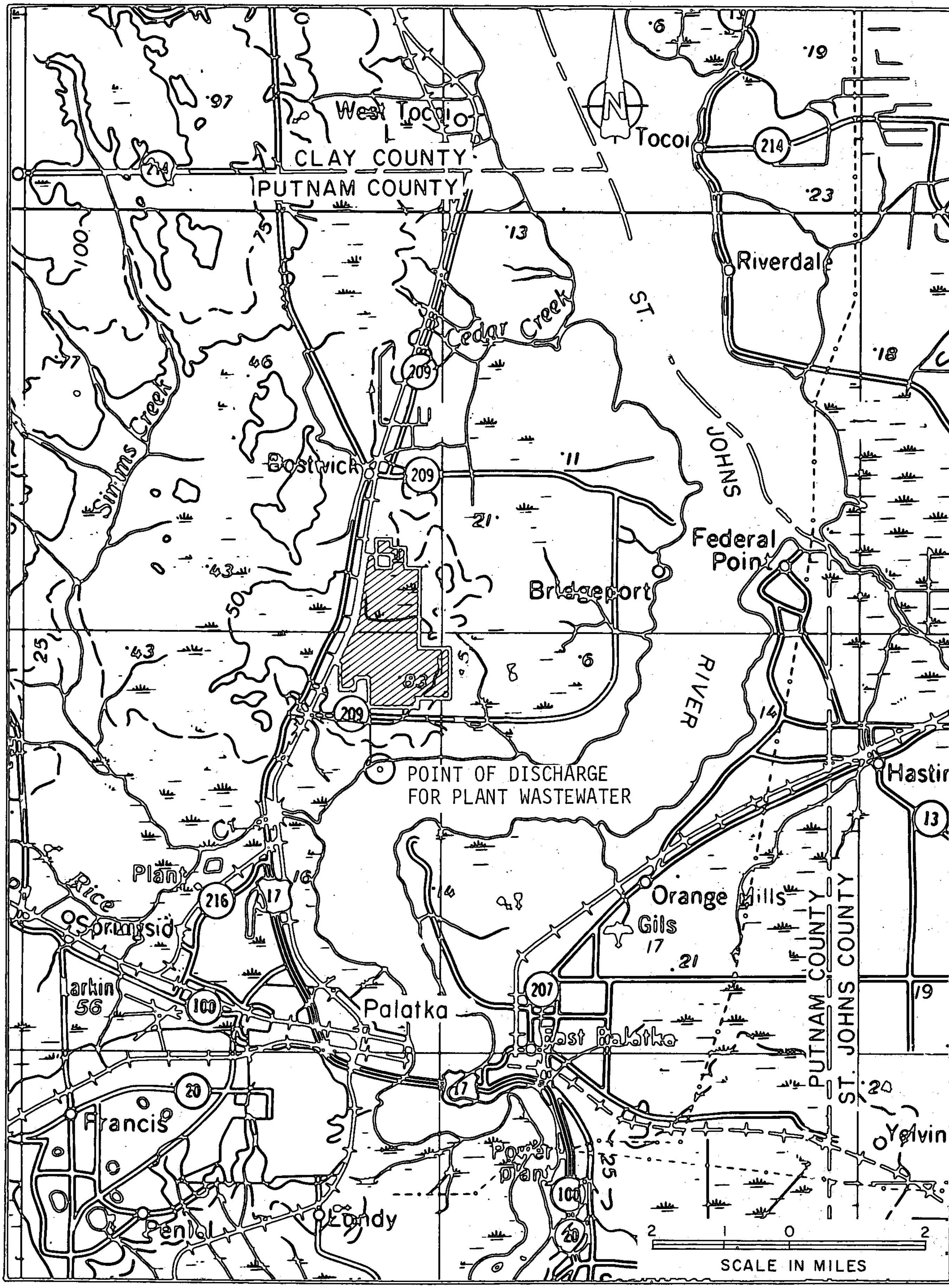
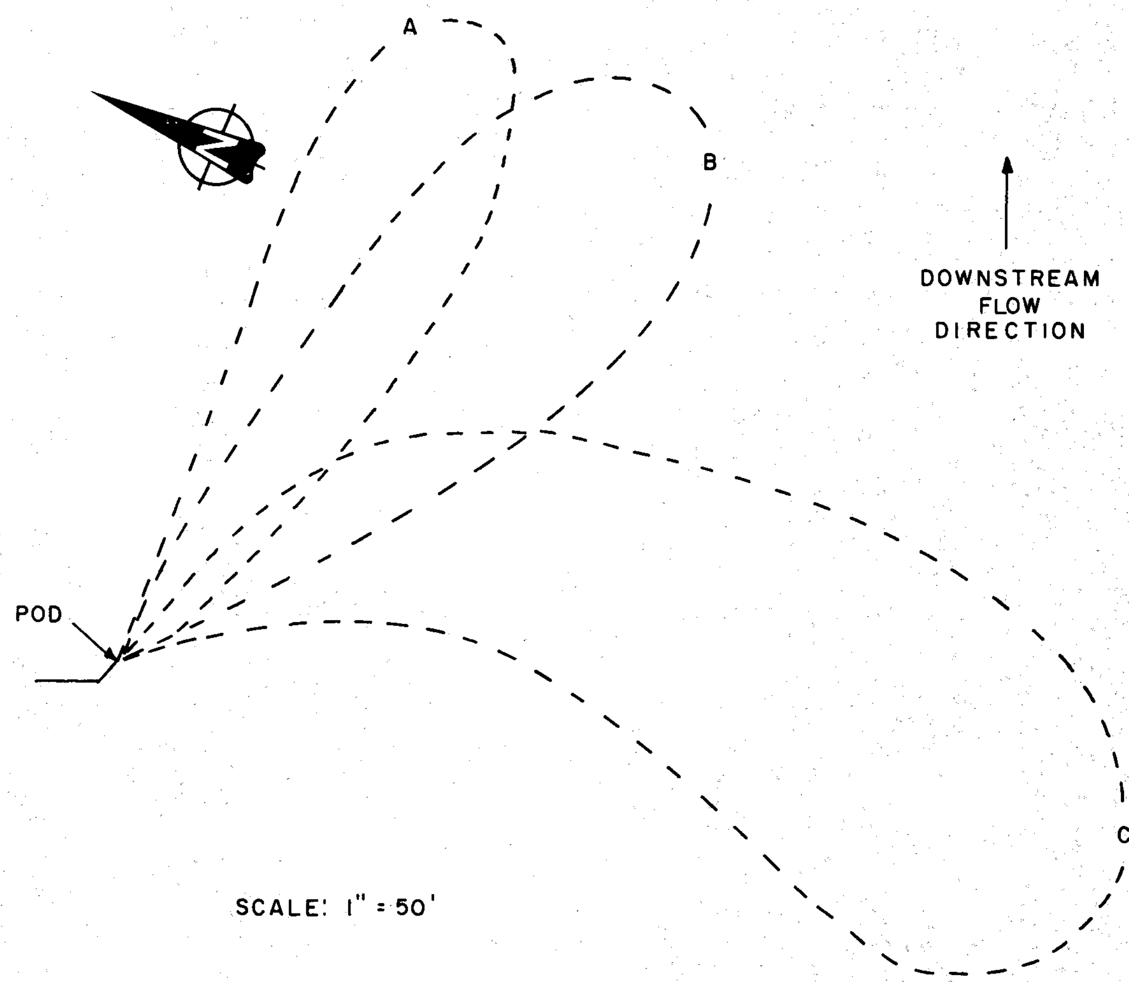


Figure 5.2-1. Location of Discharge for Plant Wastewater.



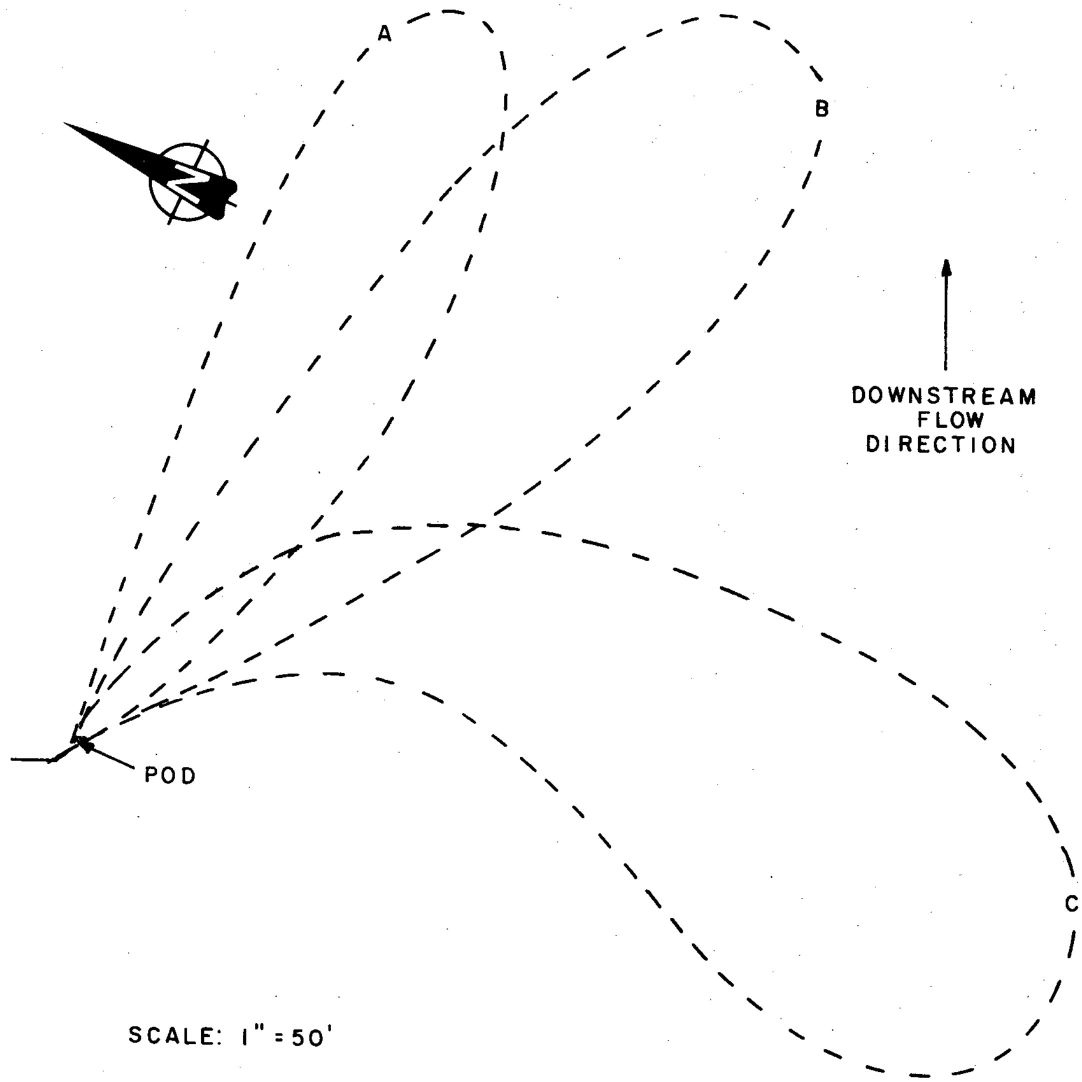
ISOTHERM	ΔT REMAINING (°F)	AREA (SQ. FT.)	AMBIENT VELOCITY (FT/SEC)
A	1.0	7000	+0.2
B	1.0	9000	0.0
C	1.0	16000	-0.2

AMBIENT TEMPERATURE = 59°F

WASTEWATER TEMPERATURE = 86°F

NOTE: FOR MORE DETAIL ON THE NEAR-FIELD THERMAL ASSESSMENT SEE APPENDIX C, SECTION C.3.4.

Figure 5.2-2. Near-Field Thermal Assessment, Winter Conditions. REVISED 3/15/79



ISOTHERM	°F TEMPERATURE	AREA (SQ. FT.)	AMBIENT VELOCITY (FT/SEC)
A	90.1	9500	+ 0.2 DOWNSTREAM
B	90.1	13000	0.0
C	90.1	16000	- 0.2 UPSTREAM

AMBIENT TEMPERATURE = 90°
WASTEWATER TEMPERATURE = 93°F

NOTE: FOR MORE DETAIL ON THE NEAR-FIELD THERMAL ASSESSMENT SEE APPENDIX C, SECTION C.3.4.

Figure 5.2-3. Near-Field Thermal Assessment, Summer Conditions. REVISED 3/15/79

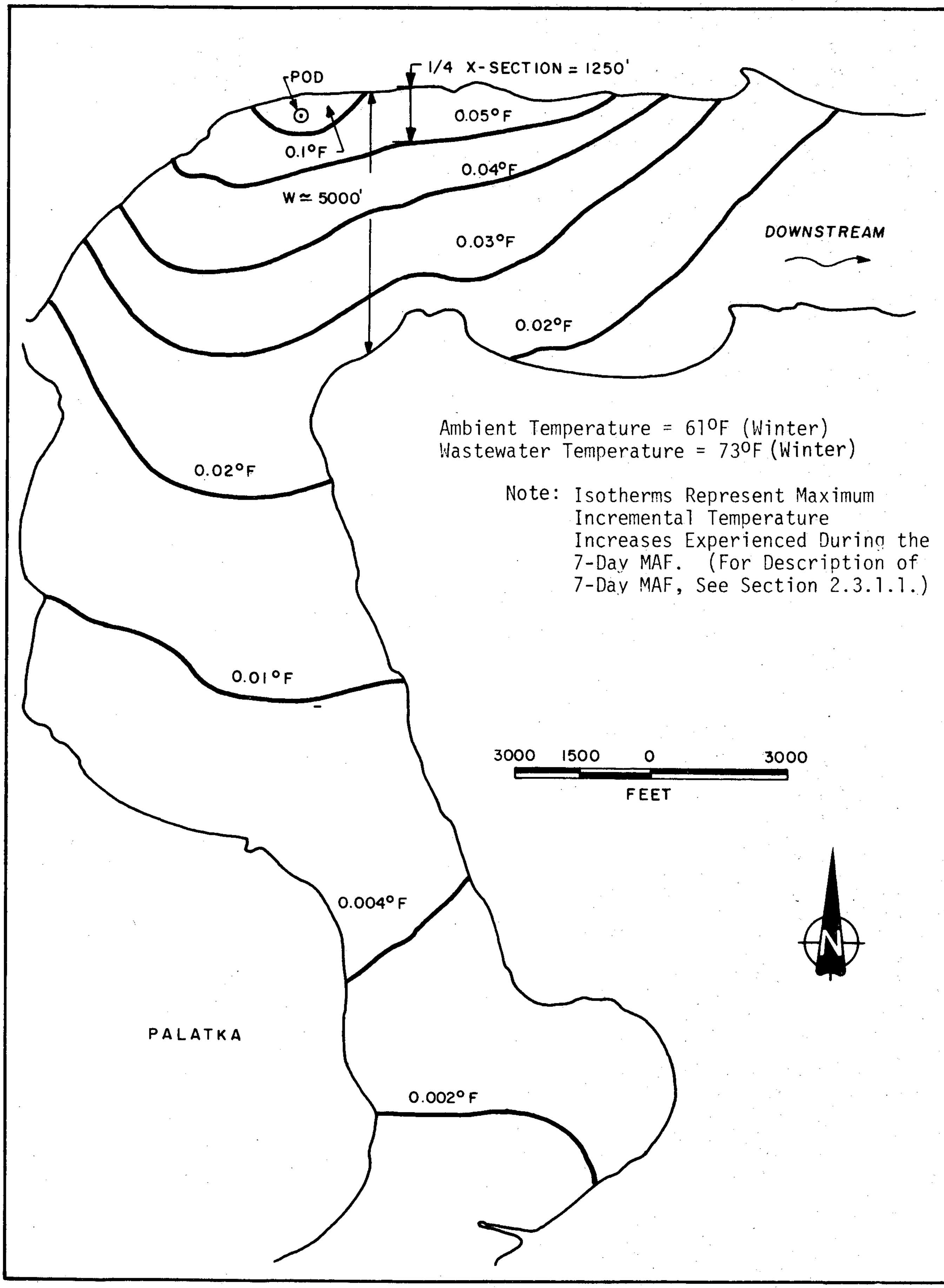


Figure 5.2-4. Thermal Impacts-Far Field Analysis.

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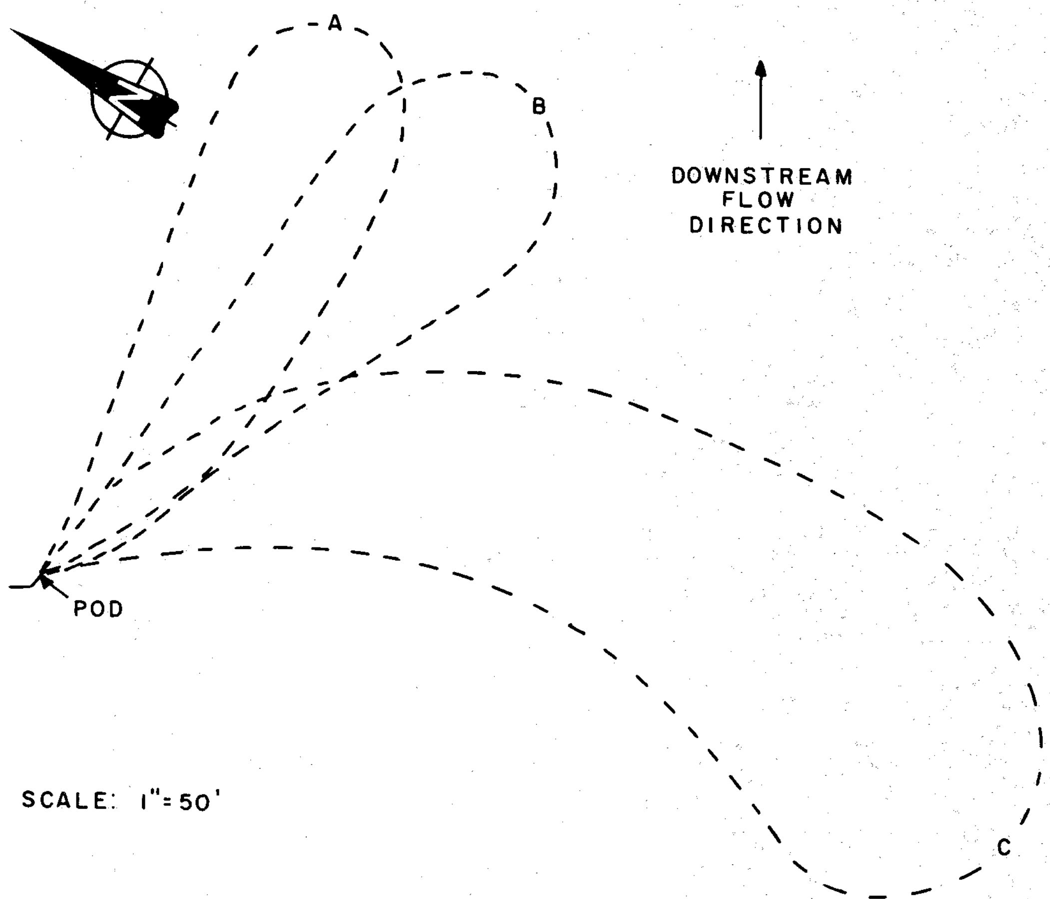

ISOPLETH	% OF ORIGINAL EXCESS REMAINING @ ISOPLETH	AREA (FT^2)	AMBIENT VELOCITY (FT/SEC)
A	4	5600	+0.2 DOWNSTREAM
B	4	7000	0.0
C	4	15000	-0.2 UPSTREAM

Figure 5.2-5. Conservative Substance Isopleths, Near-Field Assessment.

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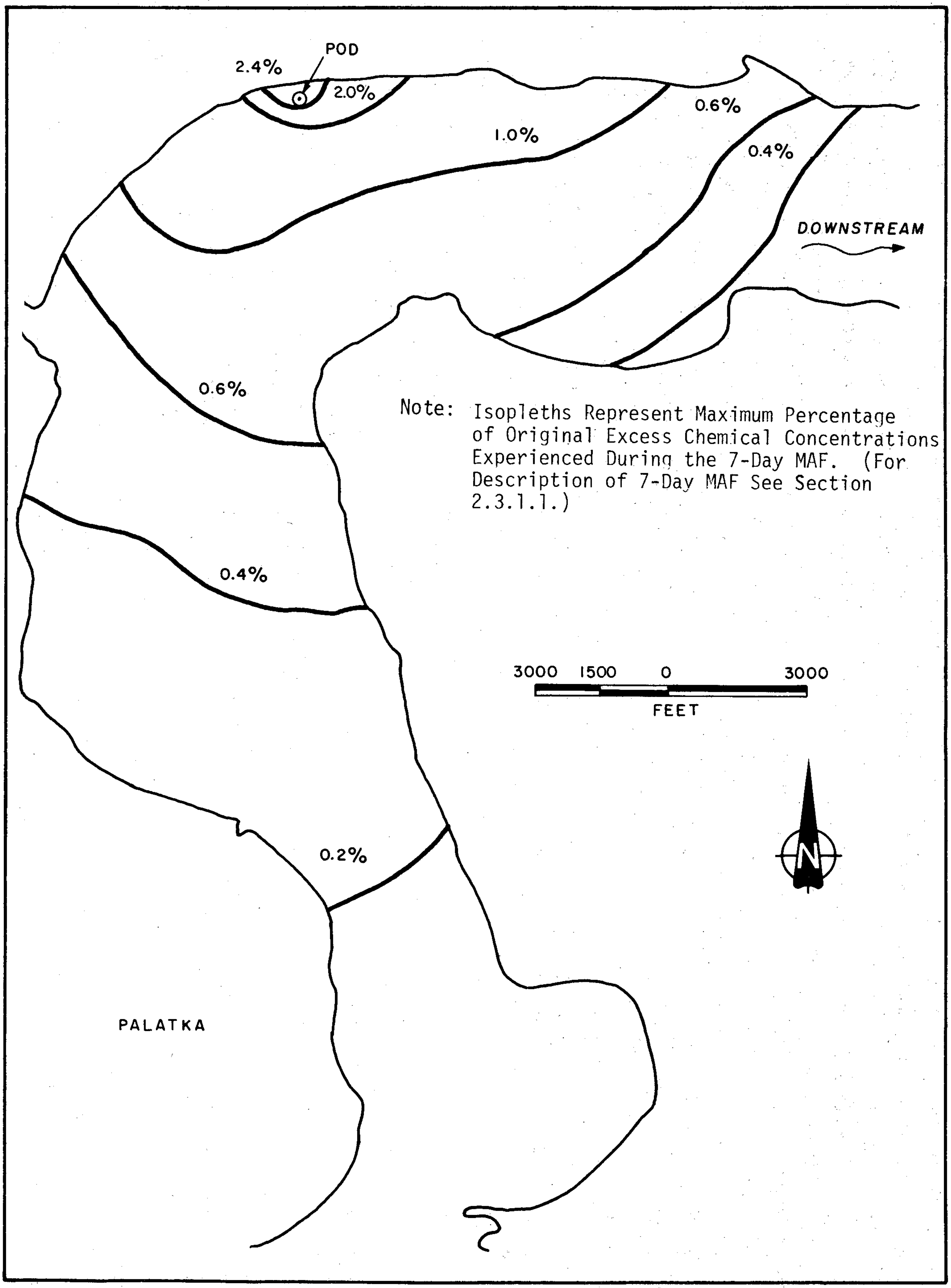

Figure 5.2-6. Chemical Impacts-Far Field Analysis.

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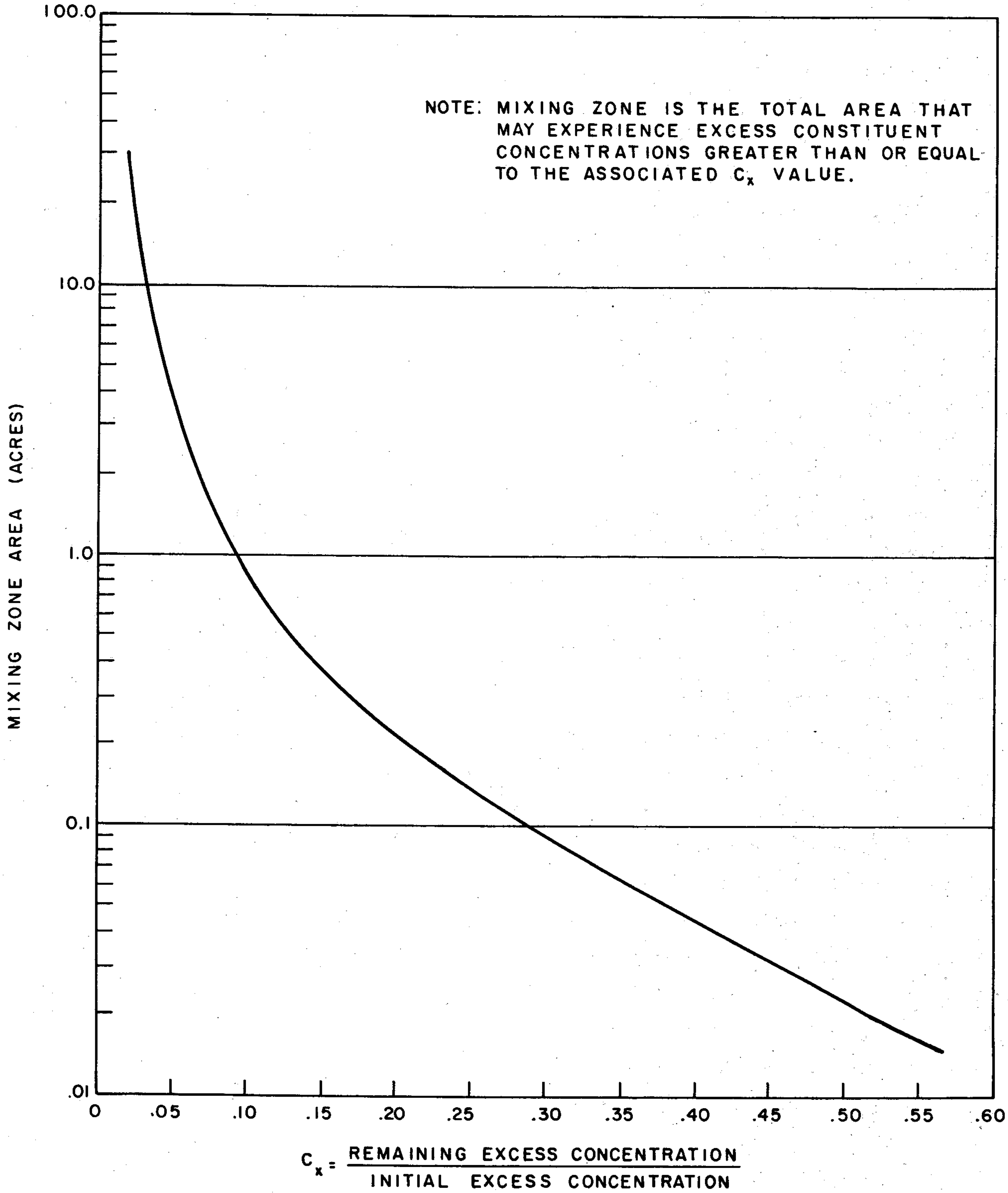
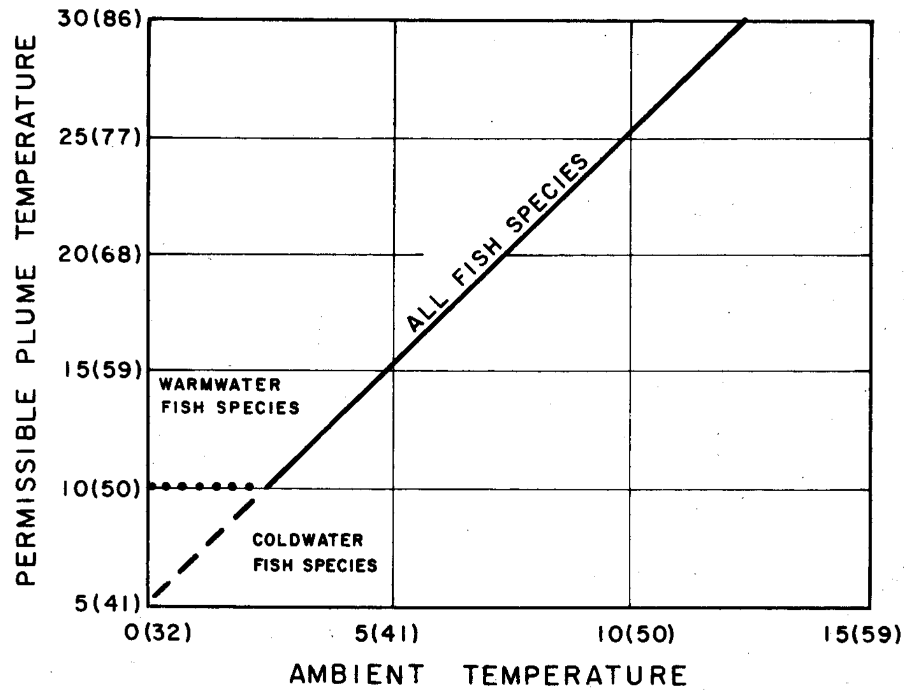


Figure 5.2-7. Remaining Excess Constituent Concentration Versus Mixing Zone.



Source: USEPA, 1976.

Figure 5.2-8. Nomograph to estimate maximum winter weekly average permissible temperature of plumes for various ambient temperatures, °C (°F).

5.3 PLANT SERVICE WATER SYSTEM

The plant serivce water will be supplied by two Floridan aquifer wells. The average daily withdrawal rate will be 590 gpm (0.85 MGD) and the well pumps will have a 1500 gpm capacity for peak requirements.

Computations were made of the projected drawdowns resulting from ground water withdrawals of 410 gpm from two Floridan aquifer wells. The computations were based on a transmissivity of 46,000 gpd/ft., a storage coefficient of 0.001, and a leakance factor of 0.001 gpd/ft^3 (Appendix L). A 30-year pumping period was assumed. The projected drawdowns were calculated using the unsteady leaky artesian equation (Hantush and Jacob, 1955).

Potential lowering of off-site potentiometric levels is minor. The nearest inventoried off-site wells that withdraw water from the Floridan aquifer are A-21 (a livestock well) approximately 3800 feet north the Production Test Well (PTW); D-1 (domestic well) approximately 5800 feet south of PTW; and A-6 (domestic well) located approximately 7000 feet north of PTW (Appendix D, Figures D-7 and D-9). At least one domestic well also exists near A-21. The projected drawdowns in these wells from pumping 205 gpm in each of two plant service water wells was computed not to exceed 1.75 feet and 2.5 feet in wells A-21 and D-1, respectively, and not to exceed 1.0 feet in well A-6.

The potential lower potentiometric levels in off-site wells should not cause a significant increase in the power required for pumping lifts. The projected drawdowns are not expected to result in any significant upconing of salt water beneath the plant service water wells or lateral migration of higher chloride Floridan aquifer water from the east.

5.4 PLANT LIQUID EFFLUENT SYSTEM

5.4.1 Chemical Waste System

The flow diagram of plant chemical wastewater sources is shown in Figure 3.4-1. Based on the methodology given in Appendix C.3.1, the chemical quanity of the ash pond effluent before and after treatment is given in Appendix C, Att. C-1, Table VB. The ash pond effluent will be discharged at an average rate of approximately 500 gpm (1.1 cfs) with a maximum of 1200 gpm (2.7 cfs).

Discharge Criteria

Standards of performance to control the quantity or quality of pollutants discharged in the chemical waste streams entering the bottom ash pond are contained in "Effluent Guidelines and Standards for Steam Electric Power Generating Point Sources" (40 CFR 423). These quidelines include criteria for discharges from the following waste streams entering the bottom ash pond: low volume wastewater, bottom ash transport water, metal cleaning wastes, boiler blowdown, and contaminated runoff. Criteria exists for pH, TSS, oil and grease, copper, and iron. The standards specify that in the event waste streams from various sources are combined for treatment or discharge, the quantity of each pollutant or pollutant property attributable to each controlled waste source shall not exceed the specified limitation for that waste source.

The 500 gpm (1.1 cfs) of treated chemical wastewater will be discharged to the St. Johns River along with the cooling tower blowdown and sanitary wastewater. The chemical concentrations in the total plant wastewater stream discharged into the St. Johns River are shown in Appendix C, Att. C-1, p. II-6 and II-7.

5.4.2 Sanitary Waste System

The sanitary wastewater treatment system will have an average flow of 6.25 gpm (.001 cfs) with a maximum of 9.7 gpm (.0022 cfs). Trace elements present in the ground water utilized in the plant potable water supply will be present in the sanitary effluent. In determining sanitary effluent quality, the maximum ground water chemical constituent concentrations were utilized assuming no reduction by the well water pretreatment system. Further, it was assumed that only TSS, phosphorus, nitrate and BOD_5 will be controlled in the sanitary treatment facility. The water quality of the ground water and the effluent from the treatment facilitiy is summarized in Appendix C, Att. C-1, Table VC.

The 500 gpm of treated sanitary wastewater will be discharged to the St. Johns River along with the cooling tower blowdown and ash pond wastewater. The chemical concentrations in the total plant wastewater stream discharged into the St. Johns River are shown in Appendix C, Att. C-1, p. II-6 and II-7.

5.5 GROUND WATER HYDROLOGY IMPACTS

5.5.1 Sources of Potential Impacts

There are four potential sources of impacts to ground water at the site. These are: (1) Disposal via landfilling of coal combustion and flue gas desulfurization wastes (fly and bottom ash, and scrubber sludge); (2) disposal via percolation field of stack wash, air preheater wash, boiler fireside wash and the boiler blowdown tank; (3) seepage from the coal storage area; and (4) seepage from the dredge disposal area. The potential impacts relative to dredge disposal are discussed in Section 4.4. The approximate locations of these areas are shown on Figure D-10 (Appendix D) in relation to the surface drainage basins in which they are located and the general direction of ground water flow.

5.5.2 Methodology

The evaluation of potential ground water impacts addressed in this section considers site specific parameters such as ground water velocity and flow rates, chemical properties of the soil (cation exchange, etc.) and dilution potential. The coal source has been identified and the chemical analyses of the coal served as input to an analytical evaluation of the potential impacts upon the ground water system and the ability of the site to assimilate the proposed method of plant operation. The principal criteria used in evaluating the site with respect to ground water was to determine the impact upon ground water quality at the property boundary in the direction of ground water flow.

5.5.3 Waste Storage Area

When filling is complete, the area will encompass 275 acres and will have an average thickness of approximately 58 feet. Approximately 16,000 acre-feet of waste material will be disposed of which approximately 30 percent will consist of fly and bottom ash and 70 percent will consist of SO_2 scrubber sludge. The bottom ash and the scrubber sludge will be dewatered prior to disposal and the water will be returned to the plant water system. The sludge and bottom ash will be dewatered further by mixing with dry fly ash until a solids content ranging from 55-80 percent is attained. This material is normally referred to as being "physically stabilized." Part of this material will be mixed with lime or cement to form a cementatious product (typically referred to as chemically stabilized) which will be used to form the base and the dikes of the waste storage area (Section 3.8).

The degree of impact of the waste storage area upon ground water will depend, in part, upon the ability of precipitation to infiltrate the disposed waste and permeate to the underlying water table aquifer (Layer 1). The permeability of the cementatious base is low and should act to retard the movement of constituents to the water table aquifer. During the early stages of filling, when the cementatious base is being deposited, the seepage to the water table should not exceed 2 in/yr; as the thickness of the disposal area increases, the seepage potential should eventually increase to a maximum of approximately 6 in/yr.

The potential migration of leachate from the waste storage area was evaluated using the site hydrogeologic parameters, and the analytical techniques presented in Appendix D.7. The results of the leachate migration analysis is given on Table D-22 (Appendix D). The assumed concentrations of the chemical constituents are given. Also given are the estimated concentrations of the constituents at the boundary of the site. The concentrations of all the chemical constituents evaluated were estimated to be within State of Florida ground water quality criteria, and significant impacts to off-site ground water quality are not anticipated with respect to the waste storage area.

5.5.4 Coal Pile Storage Area

The coal pile encompasses approximately 50 acres. The majority of the coal will be stored in the inactive (dead storage) pile. The coal will be maintained at a height of approximately 45 feet.

A large percentage of the precipitation falling on the pile will tend to infiltrate the pile due to its porous nature. The infiltrating water should move rapidly through the pile and upon reaching the original ground surface will either infiltrate to the ground water table or drain along the base of the pile to collection ditches located around the perimeter of the area. The potential for impact to ground water will be a function of the quantity of water which is able to infiltrate the original ground surface and permeate to the water table. It is estimated that approximately 9 in/yr will eventually reach the water table.

The analysis of the impacts upon water quality are summarized on Table D-25 (Appendix D). Of the chemical constituents evaluated, all are below the State of Florida water quality criteria at the property boundary. Sulfate concentrations were computed to increase background concentrations at the property boundary by approximately 730 mg/liter. The analysis indicated a potential impact on a nearby residential supply well. Assuming that the hydrogeologic conditions at the well are similar to those on the plant site, the increase in sulfate concentration after 35 years was calculated to be approximately 500 mg/liter.

5.5.5 Percolation Field

At this time, the design of the percolation field has not been finalized, therefore the size and shape of the field, as shown on Figure D-10 (Appendix D), is approximate.

The waste water to be disposed of in the percolation field will originate in the plant as boiler blowdown, boiler fireside wash, air preheater wash, and stack wash. The quantities to be disposed of are a continuous 40 gpm for the boiler blowdown and a batch volume of 270,000 gallons four times a year for the remaining three items.

The quantity of the waste water is variable. The boiler blowdown is projected to have a total dissolved solids content of less than 5 mg/liter, with approximately 1 mg/liter of iron, and small amounts of ammonia (Burns and Roe, Inc., 1979, personal communication). The quality of the remaining three items (the batch volume) should be similar to bottom ash sluice water. Therefore, the maximum potential impact to ground water will be the batch volumes disposed of four times per year.

The results of this analysis are summarized on Table D-23 (Appendix D). Significant impacts to ground water beyond the site boundary are not anticipated.

5.6 NOISE IMPACTS

5.6.1 Operation Noise Sources

Noise sources at large steam-electric generating stations were reviewed, and the principal indoor and outdoor noise sources were selected. The average sound levels for these sources are shown in Table 5.6-1. Outdoor noise from indoor sources was found to be negligible after the anticipated noise reduction due to building walls and is therefore not included in the table. Sound levels presented in the table are considered to be conservative estimates of power station operational sound levels. Efforts will be made during the plant design phase to utilize low-noise equipment or components. The station is scheduled to operate 24 hours, seven days per week.

Cooling tower sound levels, measured 150 meters (m) or 500 feet from an installation of natural draft units, were used for the calculations. The A-weighted sound level at 150 m for a typical cooling tower is 50 decibels (dB).

The following conceptual coal handling system was assumed for sound level calculations: a covered active storage with a traveling tripper for stocking out coal and a below-grade rotary plow feeder for reclaiming coal. This assumption is considered conservative with respect to estimating noise impacts. Typically, this type of system would have the following noise characteristics. An intermittent and high level noise source associated with coal handling as the coal car dump is operated. The coal cars are clamped, producing about 80 dB at 20 meters (70 feet) for 0.5 second followed by three seconds of a 70 dB sound level due to car rotation, and 25 seconds at 65 dB due to emptying of the car. A sound level of 70 dB due to the return of the car to the upright position for three seconds is followed by approximately 30 seconds of background ambient sound level. The total cycle time is approximately one minute. The equivalent sound level for this operation is 64.8 dB at 20 meters (70 feet).

Adding the acoustic energy for all coal handling operations provides an equivalent sound level, L_{eq}, of 44 dB at 300 m when the coal car emptying is in progress or an equivalent sound level, L_{eq}, of 39 dB at 320 m when the coal car dumping does not take place. Section 3.1.3.1 described the coal transportation system. It is assumed that the dumping of 70 to 90 coal cars takes approximately four hours.

Operation of the station will increase train traffic on the Seaboard Coast Line Railroad by one or two trains per day. As a typical freight train passes by, the equivalent sound level (L_{eq}) emitted to a receiver 30 meters from the track is estimated to be 84 dB for a duration of 100 seconds (Dames & Moore files). When passing through more populated areas where the train speed is regulated, sound levels might be lower but they will exist for longer duration.

When coal is removed from the coal storage pile, one or two loaders will be used to move the coal to the reclaim automatic feeder areas. The estimated equivalent sound level for two loaders operating together is 53 dB at 300 meters (1000 feet).

5.6.2 Operation Noise Impact

The day/night sound levels, L_{dn}, during operation of the plant are computed by adding, on an energy basis, the sound level contributions of each individual source discussed above and presented in Table 5.6-1. These computations include coal handling at the coal storage pile in order to present the most conservative case. The plant operation sound levels are extrapolated to noise sensitive areas represented by the baseline measurement locations (Figure 2.6-1). The 100 meters (300 feet) of dense woods are considered in these calculations. The results are presented in Table 5.6-2. No change in ambient day/night sound levels is anticipated except at Location 3 where a change of 1 dB is indicated.

No significant change in day/night sound levels, L_{dn}, are indicated at noise sensitive land use locations represented by the baseline measurement locations. Hence, no adverse noise impact is anticipated from the operation of the station.

Table 5.6-1

Plant Operation Source Equivalent Sound Levels at 300 Meters (1000 feet) from Plant*

Outdoor Power Block Sources	Outdoor L_{eq} (dB)**	Duration of Operation Daytime (hr)	Nighttime (hr)
Main Transformer	41		
F.D. Fan	40		
F.D. Fan Motor	41		
Total L_{eq}	41.5	15	9
Coal Handling			
Active Pile with Coal Car Dump	44	4	
Active Pile without Coal Car Dump	39	7	9
Inactive Storage Area	53	Intermittently	Intermittently
Cooling Towers (natural draft)	47	15	9

*Due to attentuation of plant walls, sound levels of indoor sources are negligible (<15 dB).

**Power Block sound levels are taken from a study for a similar station of 2 units of 600 megawatts generating capacity (R.G.&E, Reference 1). Coal handling sound levels from a previous Environmental Impact Study for PSCC (Reference 2).

Table 5.6-2

Operation Ambient Sound Levels at Baseline Meaurement Locations

Location	Background Ambient Sound Levels, dB			Contribution[a,b] to Ambient Sound Levels, dB	Operation Ambient Sound Levels, dB			Change in Ambient Sound Levels, dB		
	L_d	L_n	L_{dn}	L_d	L_d	L_n	L_{dn}	L_d	L_n	L_{dn}
1. Warner Point	43	40	47	25	43	40	47	0	0	0
2. Degeyter Motel	52	51	57	18	52	51	57	0	0	0
3. Wild Waters Trailer Park	47	39	48	30	47	40	49	0	1	1
4. On Site	43	36	44	--	On Site			On Site		
5. Mulberry and Tillman Rds.	47	35	46	24	47	35	46	0	0	0
6. Route 17	57	49	58	32	57	49	58	0	0	0

[a] Sound level includes 10 dB attenuation due to 90 meters (300 feet) of dense woods onsite surrounding the plant.

[b] Since this analysis was completed in August 1978, several design decisions have been made by SECI that have resulted in the selection of equipment with lower operating sound levels than that assumed in the analysis. Thus, the calculated sound levels are conservative.

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5.7 OTHER IMPACTS

5.7.1 <u>Transportation</u>

Plant operations will increase traffic levels in the plant vicinity. After construction is completed in 1983, the total workforce of the plant will be approximately 140 persons. The arrival of plant employees will increase traffic levels along State Route S209 (locally known as "West River Road" and "County Road C209"). Although Average Daily Traffic (ADT) along this highway is below capacity levels, peak hour traffic during morning rush hours may induce stacking problems at the intersection of U.S. Route 17 and State Route S209. This congestion may be relieved somewhat since inbound plant traffic along State Route S209 will be eastbound while commuter traffic from residential areas will be westbound toward U.S. Route 17. The addition of a traffic signal at the plant entrance on State Route S209 would help to alleviate any congestion caused by plant traffic crossing the westbound lane of State Route S209. This signal would also serve to alleviate stacking of vehicles at the intersection of U.S. Route 17 and State Route S209, since the delay to westbound traffic would give the intersection time to clear between traffic flows.

If conditions warrant, a signalized intersection at U.S. 17/SR209 may become necessary. The addition of turn lanes on U.S. Route 17 would also decrease congestion at the intersection. Normal service deliveries to the plant should have a minimal effect on traffic flows in the area since the delivery will generally occur during periods of minimal traffic flow, not during peak hours.

5.7.2 <u>Land Use</u>

<u>Loss of Productivity & Alternative Uses</u>

The plant is expected to be in operation for 35 years. During this time the uses of this land will be restricted to power generation. About 60 percent of the site will be developed while the rest of the site area will continue in its natural state.

Since 46 percent of the site is considered "developable" by the Coastal Zone Management Program, it is conceiveable that within the next 35 years it would have been developed for either residential, commercial, or heavy industrial uses. Putnam County is not expected to have excessive residential or commercial development occurring in the foreseeable future (Section 2.8.3). Therefore, the pressure to use the site tract for either type of development is uncertain. Criteria for heavy industrial siting may eliminate many areas in Putnam County. Since the Putnam Site possesses favorable characteristics for heavy industrial development such as access to transportation and water and non-conflicting land uses, its development for industry seems favorable. Therefore, there is a high probability that the Putnam Site would have been used for some type of industrial development had it not been selected for electric power development.

A majority of the site lies within an area classified as only fair to poor for food crop, pasture, and woodland uses (Figure 2.8-1). The rest of the site is rated as good for pasture and woodland uses; however, the county in general has ample area for such uses (Section 2.8.1.2), so preemption of these uses does not appear a significant factor. The soils on the site area are also rated as unsuited to recreational uses normally associated with outdoor activity. In addition, many other areas are available for recreational activity in Putnam County.

Conflicting Land Uses

There does not appear to be any conflicting land uses with the immediate site vicinity. Land uses such as residential, commercial, and institutional are considered to be incompatible with heavy industrial uses such as a power station. In general, most of the residential land uses in the site vicinity are far enough removed from the site to avoid any adverse affects which might create conflicts. The nearest residential land uses in the site vicinity are far enough removed from the site to avoid any adverse affects which might create conflicts. The nearest residential land uses to the site are located along U.S. Route 17, and State Route S209 near the St. Johns River (Figure 2.8-2). The nearest residential areas along the St. Johns River will be separated from the main plant structures by approximately 5,000 feet. Of this distance, approximately 3000 feet will remain heavily wooded and should provide a sufficient buffer zone between the plant and the residences.

5.7.3 Historic, Scenic, Cultural, and Natural Landmarks

The operation of the Seminole station should have no effect on the public lands discussed in Section 2.8.4. The operation of the plant will not interfere with any identified historic, scenic, cultural, or natural landmarks. The most noticeable impact of the plant will be the stacks and cooling tower visibility from the Hudson Wildlife Management Area Lands. Although this will intrude on the rural setting for persons hunting and hiking in the area, tree cover will serve to screen most of the facilities from view. The stack and cooling towers will be visible to boating ramps on the St. Johns River.

A detailed report of the archeological survey of the site is found in Appendix J. None of the sites discovered during the survey were deemed to be of significance and are not slated for preservation or excavation.

5.7.4 Aesthetics

Figure 3.1.2 is a view of the plant's eastern profile. An artist rendering is given as the frontispiece to Volume I. The tallest structures of the facility is the 675 foot stack. Other major components of the plant such as the boiler building, ash silos and natural draft cooling towers vary from 75 to 450 feet tall.

Screening of the plant facilities is to be accomplished by a buffer zone around the plant's perimeter (Figure 3.1-3). The buffer zone is to be composed mainly of natural vegetation supplemented by plantings where necessary. The buffer zone, in conjunction with other undisturbed areas on the site is expected to provide adequate screening of all the plant facilities excet the stack and cooling towers.

In general, the power plant facilities will not be visible from the highways in the area if the roadside has screening of 40 to 50 foot trees along side it. In areas where there are no trees of this height within 50 feet of a view, the stack and cooling towers may be visible. The futher from the facilities the viewer is, the less the tree height needs to be for effective screening. The stack and cooling towers will be visible from many of the residences along both sides of the St. Johns River, especially those with long unbroken vistas in the plant's direction. The facilities are also likely to be visible from the Community of Bostwick and may also be visible from some areas in Palatka.

5.7.5 Aviation

The plant's main source of possible impacts on aviation in the area is the 675-foot stack. To reduce the possibility of the stack infringing on take-off and landing operation at Key Larking Field, 5.7 miles southwest of the site, the Federal Aviation Administration (FAA) investigated the plant's location for features hazardous to aircraft. A permit to construct a stack up to 800 feet in height was granted on May 1, 1978 by the FAA.

Although the stack is a possible obstruction to light aircraft, the safety markings and warning lights, as required by the FAA, should minimize the hazard. It is possible that the visibility of the stack may prove valuable as a navigational aid to pilots.

5.7.6 Bird Mortality Caused by Collision with Structures

Bird mortality caused by collision with towers and other man-made structures has been well documented (Jackson and others, 1974; Stoddard and Norris, 1967; Stout, 1967; and Tordoff and Mengel, 1956). Mortality is highest during periods of migration when birds move south in the fall and back north in the spring. A considerable portion of all southward migration in eastern North America passes through Florida during the fall as Florida is located near the base of the massive Atlantic Flyway.

Studies have shown that mortality is as much as ten times greater during the fall than the spring (Brewer and Ellis, 1958). Generally, migratory birds move with weather fronts in the fall, and these fronts are frequently associated with bad weather. In general, migratory birds fly at altitudes well above man-made structures. It is during times of poor visibility, low cloud ceiling, and rain that most mortality occurs. Migrants are then forced to fly at low altitudes and, as many birds fly primarily at night, the chances of collision are greatly increased.

A majority of bird collision studies were conducted at television and radio towers, which present a different type of hazard from solid towers as the radio-type towers are equipped with guy wires. The nearly invisible guy wires greatly expand the hazard area around these towers. Frequently, birds are attracted to the warning lights on towers, and many collide with the guy wires as they fly around the tower in confusion (Mayfield, 1967; Graber, 1968). Larger birds that have been observed avoiding solid towers (Rybak and others, 1973) are not so soccessful when they encounter guy wires. The majority of birds found striking towers of any type are smaller, less agile songbirds. Few studies list waterfowl and shorebirds among the casualities (Graber, 1968). Waterfowl may travel by day or night, while many songbirds fly only at night when visibility is low.

It is difficult to estimate mortality due to collision with towers. Mayfield (1967) estimates tha one million birds are killed annually by television towers, and that this mortality amounts to "one in about 6,000 of the year's bird casualties in the United States. Proportionately, 16/1,000ths of one percent is not a significant number of deaths from a single cause." There are many more television towers in the United States than cooling towers, leading to the conclusion that mortality from the towers on the Putnam Site would be insignificant to avian populations.

Transmission lines pose a different sort of hazard to birds. They are constructed parallel to the arth's surface and may seem to present a barrier to bird movement for long distances. However, this is not the case. Resident birds learn quickly where the lines are and commonly use them as perches for resting or hunting. Transmission towers are frequently used as nesting sites as well. Several studies indicate that most birds that collide with transmission lines or towers are migrants unfamiliar with the area (Hochbaum, 1955).

While isolated cases of bird mortality may appear to be alarmingly high - up to 2500 a year at one television tower near Tallahassee (Stoddard and Norris, 1967) - most ornithologists consider bird mortality through collision with towers to be "trivial and unimportant" when compared to other causes of death (Stout, 1967; Mayfield, 1967).

5.8 MITIGATING MEASURES

Emission Control System

The proposed station will be equipped with an emission control system to control discharges of suspended particles, sulfur dioxide, and oxides of nitrogen. This system will be designed to meet New Source Performance Standards that will be promulgated by the EPA under the Clean Air Act.

Cooling Towers

The proposed station will utilize natural-draft cooling towers that will accomplish two mitigation actions. First, use of the towers will reduce thermal discharges to the St. Jonhs River to negligible amounts. Second, use of cooling towers with an associated closed-cycle cooling system, will reduce water intake volumes from about 1,900 cfs needed for a once-through cooling system to about 25 cfs, a reduction of 98 percent. Entrainment and impingement potential will be reduced a like amount compared to a once-through system.

The cooling towers will be operated to accomplish two additional mitigating affects. First, drift eliminators will be used to reduce drift losses, and attendant potential impacts, to the lowest practicable amount. Second, during cooling water chlorination treatment, blowdown valves will be closed to reduce to minimum amounts the discharge of free available chlorine.

Water Well System

Two Floridan Aquifer wells will be utilized, instead of one, to reduce localized lowering of the Floridan Aquifer. This will prevent potentiometric elevations from being lowered to below mean sea level, and will eliminate the potential for increases in salt-water encroachment.

Central Wastewater Treatment System

A central Wastewater Treatment System will be provided to treat miscellaneous plant wastewater streams to meet effluent quality standards specified by State and Federal regulations. This will reduce the potential for impacts to the aquatic ecosystem of the receiving stream.

Fugitive Dust Control

Control of nuisance dust will be accomplished by the application of water and/or dust-suppression chemicals when needed.

Sanitary Wastewater Treatment System

A sanitary wastewater treatment system will be provided to meet state regulations.

Intake Structure Design and Siting

The preferred location for the intake structure has been identified based on the considertion of least environmental impacts with respect to land use, river nagivation, terrestrial habitat, and aquatic ecological resources. The design of the intake structure will be predicated upon the best available technology with respect to minimizing entrainment and impingement potential.

Site Layout and Landscaping Plan

Clearing of the natural vegetation onsite will be kept to a minimum to reduce impacts to terrestrial communities. This will have two other mitigation effects. First, maintaining a maximum peripheral zone of native vegetation will help to attenuate noise created by the operation of onsite equipment. Second, the vegetated zone will serve as a visual barrier to improve the aesthetic characteristics of the site.

5.9 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

Listed below is a brief summary of the adverse environmental impacts expected during operation of Seminole Plant Units No. 1 and No. 2 that cannot be avoided by any practical means. Except as noted, these impacts are considered to be minor or negligible.

1. Air emissions from the plant will use up a portion of available PSD increments, but will not prevent other emission sources from locating in the area. Plant emissions will also raise prevailing ambient concentrations of some pollutants, but not to the harmful levels defined by ambient air quality standards.
2. Escape of fugitive dust from onsite activity.
3. Slight impacts to the aquatic environment from discharge of plant effluent.
4. Minimal impacts are expected to the aquatic environment from impingement and entrainment effects.
5. Minimal lowering of the potentiometric surface of the Floridan Aquifer.
6. Regulated discharge of treated plant wastewaters to the St. Johns River.
7. Consumption of land for station structures and for onsite storage of waste materials.
8. A slight increase in traffic levels on local roads and highways. Some disruption and noise impacts associated with increased rail traffic bringing fuel to the site.
9. Aesthetic impacts from tall structures and possibly the cooling tower plumes.
10. A slight increase in bird mortality caused by collision with station structures.

These unavoidable impacts are discussed in detail in Section 5.1 through 5.7, and proposed mitigating measures to reduce them are discussed in each section with a summary in Section 5.8.

5.10 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Consumption of Fuel

The commitment of coal, and relatively minor amounts of fuel oil, represents an irretrievable commitment of fossil fuel to the project. Coal is an abundant but non-renewable resource. Based on estimated average annual coal consumption, Seminole Plant Units No. 1 and No. 2 are expected to require about 114 million tons of coal in the 35-year life of the plant. The consumption of fuel oil for the purpose of initial light-off and low-load flame stabilization is expected to be 13.5 million gallons over the life of the plant.

Consumptive Use of Water

During plant operation, water is evaported in the cooling process and from the ash and sludge handling system. The evaporated water remains in the hydrologic system in vapor form until it returns to the earth as precipitation. For the purpose of this discussion, this evaporation loss is defined as the consumptive use of water which is derived from the St. Johns River and the Floridan Aquifer. Average consumptive use, based on a 0.7 load factor, is estimated at about 10,000 gallons per minute. This is equivalent to a total of 184 billion gallons over the life of the plant.

Other Resource Commitments

The proposed station will depend upon air resources for dispersion of heat, particulates, sulfur oxides, nitrogen oxides, and other air pollutants. The station will also depend upon the St. Johns River as the water source and for dispersion of plant effluents. The station will required land area for the main structures and for the disposal of ash and scrubber sludge waste materials. Other resources include land and vegetative and wildlife resources associated with the clearing operations for main plant structures and the waste disposal area.

5.11 REFERENCES

Altshuller, A.P., 1976, Regional transport and transportation of sulfur dioxide to sulfates in the U. S. Journal of the Air Pollution Control Association, Vol. 26, No. 4, p. 318-324.

Brewer, R., and Ellis, J. A., 1958, An analysis of migrating birds killed at a television tower in east-central Illinois, Auk 75:400-414.

Burns and Roe, Inc., 1979. Personal communication.

Cairns, Jr., J., 1956, Effects of increased temperature on aquatic organisms. Industrial Wastes, 1:50.

Federal Water Pollution Control Administration, 1967, Temperature and aquatic life. Laboratory Investigations No. 6, Technical Advisory and Investigations Branch, Cincinnati, Ohio.

Florida Department of Environmental Regulation and PEDCo Environmental, Inc., 1978, Air quality monitoring and data assessment. Prepared for Florida Sulfur Oxides Study, Inc.

Florida Sulfur Oxides Study, Inc., 1978, Final report of Florida Sulfur Oxides Study. Prepared for Florida Environmental Regulation Commission.

Graber, R. R., 1968, Nocturnal migration in Illinois - different points of view. Wilson Bulletin, 80:36-71.

Heinle, D. R., 1969, Temperature and zooplankton. Chesapeake Sci., 10: 186-209.

Hochbaum, H. A., 1955, The travels and traditions of waterfowl, Univeristy of Minnesota Press, Minneapolis.

Hynes, HBN, 1972, The essay of running water. University of Toronto Press. Toronto, Canada, 555p.

Jackson, W. B., Rybak, E. J., and Vessey, S. H., 1974, Vertical barriers to bird migration, a conference on the biological aspects of the bird/aircraft problem, Bowling Green, Ohio.

Klein, D. H., and others, 1975, Pathways of thirty-seven trace elements through coal-fired power plant. Environmental Science and Technology, Vol. 9, No. 10, p. 973-979.

Mayfield, H., 1967, Shed few tears. Audubon, May-June, p. 61-65.

Moore, D. J., 1975, Recent Central Electricity Generating Board research on environmental effects of wet cooling towers, in Cooling tower environment - 1974. U. S. Energy Research and Development Administration, Technical Information Center, CONF-740302, p. 205-219.

National Academy of Sciences, National Academy of Engineering, 1974, Water Quality Criteria, 1972. A report of the Committee on Water Quality Criteria. U. S. Government Printing Office. Washington, D. C.

Rybak, E. J., Jackson, W. B., and Vessey, S. H., 1973, Impact of cooling towers on bird migration. Proceedings of sixth Bird Control Seminar, Bowling Green, Ohio, p. 187-194.

Shirazi, M. A., and Davis, L. R., 1974, Workbook of thermal plume predicition, Vol. 2, EPA-R2-72-005b.

Stoddard, H. L., Sr., and Norris, R. A., 1967, Bird casualties at a Leon County, Florida TV tower: an eleven-year study. Bulletin, Tall Timbers, Res. Sta. No. 8.

Stout, I. J., 1967, The nature and pattern of nonhunting mortality in fledged North American waterfowl, M. S. thesis, Virginia Polytechnic University, Blackburg, Virginia, 329 p.

Tordoff, H. B., and Mengell, R. M., 1956, Birds killed in nocturnal migration, University of Kansas publication, Museum of Natural History.

U. S. Environmental Protection Agency, 1973, Water quality criteria, 1972, U. S. Environmental Protection Agency, R3/73-033.

______________, 1974, Development documents for effluent limitations guidelines and new source performance standards for the steam electric power generating point source category, 440/1-74 029-a.

__________, 1975, Position paper on regulation of atmospheric sulfates. Office of Air Quality Planning and Standards, Publication No. EPA-450/2-75-007.

____________, 1976, Development Document for Best Available Technology available for the location, design, construction, and capacity of cooling water intake structures for minimizing adverse environmental impact. EPA 440/1-76/015a. Washington, D.C.

__________, 1977a, Guidance for determining best technology available for the location, design, construction and capacity of cooling water intake structures for minimizing adverse environmental impact, Section 316(b) P.L. 92-500 (draft) Washington, D.C.

__________, 1977b, User's manual for single-source (CRSTER) model. Office of Air Quality Planning and Standards, Publication No. EPA-450/2-77-013.

__________, 1978, Policy statement (January 1978) by Walter Barber, Deputy Assistant Administrator for Air Quality Planning and Standards.

__________, 1978, STORET water quality data for Rise Creek at U. S. Route 17 Bridge, Florida Department of Environmental Regulation, unpublished.

U. S. Fish and Wildlife Service, 1974, Navigable Waters Handbook N.P.

U. S. Public Health Service, 1969, Air quality display model. Prepared for National Air Pollution Control Administration by TRW Systems Group, Contract No. PH-22-68-60.

Weiss, R. E., and others, 1977, Sulfate aerosol: its geographical extent in the midwestern and southern United States. Science, Vol. 195, p. 979-980.

Wilson, W. E., and Others, 1977, Sulfates in the atmosphere, a progress report on Project MISTT. U. S. Environmental Protection Agency, Environmental Sciences Research Laboratory, Publication No. EPA-600/7-77-021.